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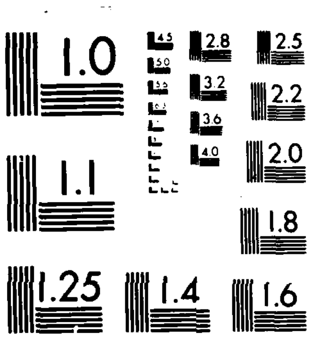

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The performance of the HMMWV is analyzed and compared to the vehicles which it will replace. A generic HMMWV is postulated. The vehicles are assessed for off-road and on-road performance in Europe and the Mid-East. The performance criteria are: Speed profiles, percentages of total terrain area in which the vehicles were immobilized, factors causing immobilization, factors limiting speed, vehicle acceleration, speed on slopes and stability during turns on side slopes. Additionally air transportability of the vehicles was evaluated.

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MOBILITY AND TRANSPORTABILITY ASSESSMENT OF A GENERIC
HIGH MOBILITY MULTIPURPOSE WHEELED VEHICLE (HMMWV)

1. INTRODUCTION

The US Army Infantry School (USAIS) is currently carrying out a Performance and Cost Analysis (P&CA) of the High Mobility Multipurpose Wheeled Vehicle (HMMWV). AMSAA was requested to support this effort by conducting performance analyses of the HMMWV and those vehicles which the HMMWV will supplant in its various roles. The vehicles or combinations of vehicles considered in this study are:

HMMWV Utility Truck
HMMWV Utility Truck Mounting the S250 Shelter @ 3600 pounds
HMMWV Utility Truck Towing the M101 3/4-ton Trailer
M151 1/4-ton Truck
M151 1/4-ton Truck Towing the M416 1/4-ton Trailer
M561 1-1/4 ton Truck
M561 1-1/4 ton Truck Towing M101 3/4-ton Trailer

Since the HMMWV vehicles are still undergoing competitive evaluation, it was decided, for analysis purposes, to use a generic form of the HMMWV having attributes representative of all of the candidate vehicles, but peculiar to none. In addition, it was felt that the performance of the cargo loaded HMMWV truck and the HMMWV weapons carrier mounting the TOW launcher would be similar and therefore the TOW vehicle was not evaluated as such.

The mobility assessment encompassed vehicle performance off-road and on-road in Europe and the Mid-East. The European terrain over which the vehicles were exercised is located in West Germany and the Mid-East terrain in Jordan. Conditions considered were dry, wet and snow covered surfaces in West Germany and dry and wet surfaces in Jordan.

Results of the assessment are presented in the form of speed profiles and a listing of the percentages of the total area in which the vehicles were immobilized. The factors which caused immobilization as well as those which limited speed are also indicated.

On-road performance is shown as average speeds over primary and secondary roads and trails. The road networks over which the speeds were computed are located in West Germany and Yuma, Arizona. The Yuma network was selected because it resembles Jordan roads and because no Jordan network is available. Both off-road and on-road vehicle performance were obtained by exercising the vehicles in the Army Mobility Model. Finally, both off-road and on-road performance were employed to determine tactical high, tactical standard and tactical support mobility levels.

Additional measures of performance which are not provided as specific outputs of the Army Mobility Model are also furnished. These are vehicle acceleration and maximum speed on slopes. Stability during turns on side slopes was also investigated for the M151, M561 and the HMMWV when carrying the S250 shelter.

During the course of the mobility analysis a request was received from USAIS for additional HMMWV P&CA analysis support in the form of a transportability evaluation of the HMMWV and certain base case vehicles. Only air transport was to be considered. The vehicles, aircraft and operational areas are listed below:

a. Vehicles evaluated:

Base Case	HMMWV
M561, 5/4-ton, truck	
M151, 1/4-ton, truck	HMMWV, TOW TOW System:
M151, 1/4-ton, TOW Carrier	
M151, 1/4-ton, Missile Carrier	
M416, 1/4-ton, Trailer	

b. Aircraft to be considered:

(1) Internal Loads - C130, C141B, C5A, CH-47D

(2) External Loads - CH-47D, UH-60, UH-60 (BI)*

c. Scenarios to be considered:

(1) Europe

(2) Mid-East

*Block Improvement

The objectives of the transportability assessment were to determine:

a. Based on loading only one type of vehicle system, the number of each type that can be loaded on the C130, C141B, C5A and the CH-47D aircraft.

b. Whether the CH-47D, UH-60 and UH-60 (BI) can sling load each of the vehicle systems in the Europe and Mid-East areas taking into consideration pressure altitude, temperature and round trip distance. Conditions under which sling loading cannot be effected should be noted.

Section II contains a discussion of the various aspects of the mobility assessment. In Section III, air transport of the various vehicles in the designated aircraft in the Mid-East and Europe is evaluated. Characteristics of the generic HMMWV and speed profiles of actual and cumulative average speeds of

the various vehicles are presented in Appendix A and payload range curves for the helicopters considered in Appendix B.

2. MOBILITY EVALUATION

2.1 Off-Road Performance.

The Army Mobility Model off-road module was used to assess performance of the various vehicles in the West Germany and Jordan terrains. The Army Mobility Model is composed of two modules, the aforementioned off-road module and an on-road module. The off-road module computes the maximum feasible first-pass speed for a single vehicle in a single areal patch or terrain unit. Terrain units are areas in which certain attributes of the terrain such as soil strength, slope, roughness, obstacles and vegetation fall within certain rather narrow ranges and thereby can be characterized by a single representative value for each feature. These attributes are then considered to be homogeneous throughout the unit.

The vehicle is specified in terms of mechanical, geometric and inertial characteristics that determine its interaction with the terrain. These include such factors as weight distribution, track or wheel size, approach and departure angles, tractive force as a function of speed, and ride and obstacle performance curves. Driver inputs are considered in terms of his ability to stand shock and vibration and his reaction to certain situations affecting his driving behavior.

With this information at hand, the off-road module computes the maximum vehicle speed in each terrain unit. The terrain unit speeds are cumulated in a speed profile. In these profiles, the terrain units are ordered so that they progress from the easiest to the most difficult to negotiate. The profiles show both the actual and cumulative average speeds as a function of the percentage of terrain traversed. Cumulative average speed is the average speed a vehicle can sustain as a function of the total area it avoids, under the assumption that it avoids the areas posing the greatest impediment to its motion.

An additional output of the off-road module is a listing of the speed limiting and immobilizing factors and the percentage contribution of each factor.

All the vehicles were exercised in both the off-road and on-road modules of the Mobility Model. Tables 1-3 show the cumulative average speeds achieved by each vehicle for each condition over the easiest 50 percent (V_{50}) and easiest 90 percent (V_{90}) of the terrain, and indicate the fraction of the terrain that is not negotiable under each condition.

Two sets of abbreviations appear in this report. The first set appears in the body of the report and is used because of its compactness and clarity. The second, imposed by additional computer plotter constraints, appears on the speed profiles presented in the Appendices. These abbreviations are:

VEHICLE/COMBINATION	ABBREVIATION IN REPORT TEXT	PLOTTER ABBREVIATION
HMMWV Utility Truck	HMMWVG	HMMWVG
HMMWV Utility Truck Mounting S250 Shelter	HMMWV W/SHELTER	HMMWVSH
HMMWV Towing M101 Trailer	HMMWV W/M101	HMMWV W/M1
M151 1/4-ton Truck	M151A2	M151A2
M151 1/4-ton Truck Towing M416 Trailer (AMMO)	M151 W/AMMO TRL	M151 W/AMM
M151 1/4-ton Truck Towing M416 Trailer	M151 W/M416	M151 W/TRL
M561 1-1/4 ton Truck	M561	M561
M561 1-1/4 ton Truck Towing M101 Trailer	M561 W/M101	M561 TR

Table 1 shows that the HMMWV carrying cargo or the S250 shelter or towing the M101 has higher V_{50} speeds than the other vehicles on dry surfaces in West Germany and Jordan terrain. All vehicles are immobilized by the time 90 percent of either area is traversed, hence no V_{90} values are given. The HMMWV has a lower incidence of immobilization in the German terrain, but a higher percentage of no-go's in Jordan. The Jordan terrain is rougher and the configuration of the HMMWV is such that the obstacles encountered in Jordan immobilize it more frequently than the M151. The M151's shorter wheelbase and slightly better breakover angle probably contribute to this.

Data presented in Table 2 show the degrading effects of wet surfaces on vehicle mobility. All vehicles experience a reduction in V_{50} speeds and an increase in the percentage of no-go's. In particular, trailered vehicles show a marked increase in no-go's on wet surfaces in West Germany. A reduction in vehicle traction occurs due to the weakness of the soil when wet, resulting in increased immobilization. This is especially true of the West German terrain which receives considerably more rainfall in the wet season than does Jordan, and hence has greater moisture content in the soil.

Table 4 contains a listing of the Vehicle Cone Index (VCI_1) values for the various vehicles studied. The VCI_1 value is the soil strength required to support one pass of the vehicle in question. This value enters into the expression used to determine the magnitude of the reactive force exerted by the soil in opposition to the tractive or propulsive force imposed on it by the vehicle. Other things being equal,the lower the VCI_1, the smaller the reactive force the soil must develop to allow the vehicle to move. Consequently, the

TABLE 1

PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY-DRY V_{50} MPH	GERMANY-DRY V_{90} MPH	GERMANY-DRY PERCENT* NOGO	JORDAN-DRY V_{50} MPH	JORDAN-DRY V_{90} MPH	JORDAN-DRY PERCENT* NOGO
HMMWV W/M101	18.6	NO-GO	12.3	13.7	NO-GO	17.4
M151 W/M416	16.4	NO-GO	15.4	10.7	NO-GO	13.2
M561 W/M101	15.1	NO-GO	11.5	12.5	NO-GO	16.4
M151 W/AMMO TRL	16.5	NO-GO	14.8	10.7	NO-GO	13.1
M151A2	17.9	NO-GO	11.7	10.8	NO-GO	13.1
M561	15.8	NO-GO	10.2	12.5	NO-GO	16.4
HMMWVG	20.3	NO-GO	10.0	14.0	NO-GO	16.5
HMMWV W/SHELTER	19.7	NO-GO	10.0	13.9	NO-GO	16.5

*NO-GO UNDER V_{50} OR V_{90} COLUMN INDICATES THE VEHICLE WAS IMMOBILIZED BEFORE IT REACHED THE 50% OR 90% AREA POINT AND CONSEQUENTLY HAS NO SPEED AT THAT POINT.

TABLE 2

PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY-WET V_{50} MPH	GERMANY-WET V_{90} MPH	GERMANY-WET PERCENT* NOGO	JORDAN-WET V_{50} MPH	JORDAN-WET V_{90} MPH	JORDAN-WET PERCENT* NOGO
HMMWV W/M101	14.2	NO-GO	28.6	12.5	NO-GO	19.0
M151 W/M416	11.5	NO-GO	30.1	9.7	NO-GO	15.5
M561 W/M101	12.3	NO-GO	25.5	11.9	NO-GO	18.1
M151 W/AMMO Trl	11.6	NO-GO	32.3	9.6	NO-GO	19.0
M151A2	14.5	NO-GO	19.8	10.1	NO-GO	14.0
M561	13.8	NO-GO	18.4	12.2	NO-GO	16.8
HMMWVG	16.3	NO-GO	18.6	13.0	NO-GO	16.8
HMMWV W/SHELTER	16.1	NO-GO	18.3	13.0	NO-GO	16.8

TABLE 3

PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY-SNOW V_{50} MPH	V_{90} MPH	PERCENT* NOGO
HMMWV W/M101	NO-GO	NO-GO	50.3
M151 W/M416	NO-GO	NO-GO	54.9
M561 W/M101	7.8	NO-GO	38.7
M151 W/AMMO TRL	NO-GO	NO-GO	63.0
M151A2	16.8	NO-GO	26.7
M561	11.5	NO-GO	25.0
HMMWVG	18.6	NO-GO	25.2
HMMWV W/SHELTER	17.3	NO-GO	25.4

vehicles having the lower VCI_1 will be able to negotiate weaker soils with fewer incidents of immobilization than those having the higher VCI_1 values. However, as shown in Table 4, there are no significant differences among the vehicles considered here.

Vehicle performance on snow covered surfaces in West Germany is even more degraded, with all but one of the trailered vehicles showing no-go's at the V_{50} point. However, it may be noted that the HMMWV vehicles without trailers, and the M151, show higher V_{50} speeds in snow than on wet surfaces. This is caused first by an assumed attenuation of surface roughness by the snow cover, and secondly by reduced motion resistance with snow over frozen ground as compared to wet soil. However, the percentage of no-go's is higher in the snow, indicating more difficulty in traversing the more severe terrain.

In general, the HMMWV vehicles had higher V_{50} speeds than the comparison vehicles and fewer no-go's.

Tables showing factors that cause no-go's and factors that limit speeds are contained in Appendix A. Profiles of actual and cumulative average speeds are also contained in this appendix.

2.2 On-Road Performance.

Average speeds of the various vehicles on the West Germany and Yuma road networks are presented in Tables 5-7. Speeds are shown over primary and secondary roads and trails for the same surface conditions considered for off-road travel. Since the Yuma road network represents the Mid-East roads, performance in snow was not evaluated for this network.

The on-road module of the Army Mobility Model was used to perform this assessment. The on-road module is similar in concept to the off-road module. Factors such as road type, surface strength, curvature and surface roughness are used to characterize the road units. Vehicle data include geometric, inertial and mechanical characteristics. The model output is vehicle speed. The three classes of road mentioned are identified as:

Class 1 - Primary: surfaced all weather road, two lanes or more.

Class 2 - Secondary: the balance of all weather roads, generally unpaved but improved, plus paved roads less than two lanes wide.

Class 3 - Trails: unimproved and fair weather roads and trails of at least one vehicle width.

The average speeds of all the HMMWV vehicles, including the one towing the M101 trailer, exceed those of the other vehicles on dry and wet roads and trails in West Germany and Yuma. On snow covered roads and trails, the HMMWV carrying cargo or the TOW weapon has higher speeds than all other vehicles, but

TABLE 4

VEHICLE VCI_1 VALUES

VEHICLE	VCI_1
HMMWV W/M101	22.5
M151 W/M416	21.2
M561 W/M101	21.5
M151 W/AMMO TRL	21.2
M151A2	18.8
M561	19.4
HMMWVG	19.4
HMMWV W/SHELTER	20.9

TABLE 5

AVERAGE SPEED ON ROADS AND TRAILS (MPH)

VEHICLE	GERMANY-DRY PRIMARY	GERMANY-DRY SECONDARY	GERMANY-DRY TRAILS	YUMA-DRY PRIMARY	YUMA-DRY SECONDARY	YUMA-DRY TRAILS
HMMWV W/M101	50.3	36.1	13.7	57.7	33.6	13.6
M151 W/M416	44.5	29.8	9.5	49.6	26.5	10.0
M561 W/M101	39.4	21.4	12.3	47.0	18.8	12.4
M151 W/AMMO TRL	41.7	29.5	9.6	45.0	26.1	10.0
M151A2	48.8	32.1	9.7	53.0	27.3	10.0
M561	44.0	23.7	12.9	50.9	19.8	12.4
HMMWVG	53.5	38.4	14.0	60.6	34.3	13.6
HMMWV W/SHELTER	51.7	37.2	13.9	59.2	33.9	13.6

TABLE 6

AVERAGE SPEED ON ROADS AND TRAILS (MPH)

VEHICLE	GERMANY-WET PRIMARY	GERMANY-WET SECONDARY	GERMANY-WET TRAILS	YUMA-WET PRIMARY	YUMA-WET SECONDARY	YUMA-WET TRAILS
HMMWV W/M101	50.3	36.1	13.6	57.7	33.6	13.6
M151 W/M416	44.5	29.8	9.5	49.6	26.5	10.0
M561 W/M101	39.4	21.4	12.1	47.0	18.8	12.4
M151 W/AMMO TRL	41.7	29.5	9.6	44.9	26.1	10.0
M151A2	48.8	32.1	9.7	53.0	27.3	10.0
M561	44.0	23.7	12.8	50.9	19.8	12.4
HMMWVG	53.5	38.4	14.0	60.6	34.3	13.6
HMMWV W/SHELTER	51.7	37.2	13.8	59.2	33.9	13.6

TABLE 7

AVERAGE SPEED ON ROADS AND TRAILS (MPH)

VEHICLE	GERMANY-SNOW PRIMARY	SECONDARY	TRAILS
HMMWV W/M101	26.8	25.4	16.2
M151 W/M416	25.1	23.0	14.6
M561 W/M101	16.3	15.7	11.6
M151 W/AMMO TRL	27.2	25.7	15.9
M151A2	30.0	29.1	18.1
M561	21.5	19.7	12.9
HMMWVG	32.9	31.1	18.3
HMMWV W/SHELTER	29.7	28.4	17.5

when the S250 shelter is added, the speed falls slightly below that of the M151. The addition of the M101 trailer to the HMMWV results in only a small reduction of speed in snow.

2.3 Tactical Mobility Levels.

One means of rating vehicle performance is to express it in terms of a "mobility level". A mobility level rating system was used in this study to evaluate the various vehicles. This system comprises five levels of mobility proposed in the HIMO [1] study. It is based on the mission requirements of the vehicle, including both the frequency of operation on various surface types and the degree of severity of terrain encountered for each surface type.

Table 8 lists the various mobility levels, the composition of the networks in West Germany and the Mid-East (percentages of off-road, road and trail travel) and the severity of the operation in terms of the terrain and roads challenged).

Since the HMMWV will have a very wide range of mission requirements in replacing both the M151 and the M561, all mobility levels from "tactical support" to "tactical high" are of interest. The speeds computed for each of these levels are shown in Tables 9 through 11 [2]. To summarize the results shown in those tables, the following observations are offered:

a. The basic HMMWV tactical mobility equals or exceeds that of the M151 and the M561 in 13 of the 15 conditions examined. Only in the Mid-East wet and dry conditions at the tactical high level does a baseline vehicle have a speed advantage and even there the advantage is less than one mile per hour.

b. The S250 shelter weight of 3600 pounds does not significantly affect the tactical mobility speeds of the HMMWV.

c. When each is towing a trailer the M561 has a slight advantage over the HMMWV at the higher tactical mobility levels.

NOTE: [1]Nuttall, C.J., Jr, and Randolph, D.D., "Mobility Analysis of Standard- and High-Mobility Tactical Support Vehicles (HIMO Study)". Technical Report M-76-3, February 1976, US Army Engineers Waterways Experiment Station, CE, Vicksburg, MS.

[2]Tables 9 through 11 indicate where vehicles cannot negotiate sufficient terrain to accommodate the tactical mobility definition. In such cases a speed of 0.1 MPH is assumed for the unnegotiable area to reflect the time penalty to provide required engineering support.

TABLE 8

NETWORK COMPOSITION AND SEVERITY AT TACTICAL MOBILITY LEVELS

FOR HIMO WEST GERMANY STUDY AREA

MOBILITY LEVELS	COMPOSITION OF NETWORK IN PERCENT				SEVERITY OF OPERATION IN TERMS OF PERCENT OF TERRAIN AND ROADS CHALLENGED			
	PRIMARY ROADS (P_P)	SECONDARY ROADS (P_S)	TRAILS (P_T)	OFF-ROAD (p)	PRIMARY ROAD (V_{PP})	SECONDARY ROADS (V_{SP})	TRAILS (V_{TP})	OFF-ROAD
HIGH-HIGH	0	0	0	100	-	-	-	V_{100}
TACTICAL HIGH	10	30	10	50	V_{100}	V_{100}	V_{100}	V_{90}
TACTICAL STANDARD	20	50	15	15	V_{100}	V_{100}	V_{100}	V_{80}
TACTICAL SUPPORT	30	55	10	5	V_{100}	V_{100}	V_{50}	V_{80}
ON-ROAD	35	60	5	0	V_{100}	V_{100}	V_{10}	-
FOR HIMO MID-EAST STUDY AREA								
HIGH-HIGH	0	0	0	100	-	-	-	V_{100}
TACTICAL HIGH	5	20	25	50	V_{100}	V_{100}	V_{100}	V_{90}
TACTICAL STANDARD	15	35	35	15	V_{100}	V_{100}	V_{100}	V_{80}
TACTICAL SUPPORT	20	40	35	5	V_{100}	V_{100}	V_{80}	V_{50}
ON-ROAD	30	40	30	0	V_{100}	V_{100}	V_{50}	-

TABLE 9

SPEED AT TACTICAL MOBILITY LEVELS

	WEST GERMANY-DRY			MID-EAST DRY		
VEHICLE	TACTICAL HIGH	TACTICAL STANDARD	TACTICAL SUPPORT	TACTICAL HIGH	TACTICAL STANDARD	TACTICAL SUPPORT
HMMWV/M101	4.1*	18.3	30.2	3.2*	15.2	22.8
M151/M416	2.3*	15.2	26.1	2.7*	10.7	18.2
M561/M101	4.6*	14.7	21.8	4.5*	13.6	17.2
M151/AMMO TRL	2.6*	15.1	25.8	3.7*	10.6	18.0
M151A2	4.5*	16.0	27.9	4.9*	10.7	18.4
M561	7.3*	15.6	22.7	4.5*	13.8	17.6
HMMWVG	9.4	19.1	32.0	4.1*	15.3	23.0
HMMWV/SHELTER	9.3	18.8	31.2	4.1*	15.3	22.9

*AREA TRAFFICABLE 90%

TABLE 10

SPEED AT TACTICAL MOBILITY LEVELS

VEHICLE	WEST GERMANY-WET TACTICAL HIGH	WEST GERMANY-WET TACTICAL STANDARD	WEST GERMANY-WET TACTICAL SUPPORT	MID-EAST-WET TACTICAL HIGH	MID-EAST-WET TACTICAL STANDARD	MID-EAST-WET TACTICAL SUPPORT
HMMWV/M101	0.9*	4.3**	29.0	1.7*	14.7	22.6
M151/M416	0.8*	3.7**	24.9	2.6*	9.9	18.0
M561/M101	0.9*	5.5**	20.2	2.7*	13.4	17.1
M151/AMMO TRL	0.8*	3.3**	24.7	1.5*	9.8	17.8
M151A2	1.4*	14.7	27.0	3.3*	10.5	18.4
M561	1.7*	14.7	22.2	4.0*	13.7	17.6
HMMWVG	1.7*	17.5	30.9	3.7*	15.1	22.9
HMMWV/SHELTER	1.7*	17.3	30.1	3.7*	15.1	22.8

*AREA TRAFFICABLE 90%

**AREA TRAFFICABLE 80%

TABLE 11

SPEED AT TACTICAL MOBILITY LEVELS

	WEST GERMANY-SNOW		
VEHICLE	TACTICAL HIGH	TACTICAL STANDARD	TACTICAL SUPPORT
HMMWV/M101	0.4*	1.8**	17.9***
M151/M416	0.4*	1.2**	9.3***
M561/M101	0.6*	2.2**	14.1
M151/AMMO TRL	0.3*	1.2**	6.0***
M151A2	0.9*	5.4**	24.9
M561	1.1*	5.9**	17.7
HMMWVG	1.1*	6.2**	26.6
HMMWV/SHELTER	1.1*	6.1**	24.5

*AREA TRAFFICABLE 90%

**AREA TRAFFICABLE 80%

***AREA TRAFFICABLE 50%

TABLE 12

SPEED VERSUS ELAPSED TIME AS A FUNCTION OF SOIL STRENGTH

VEHICLE	SURFACE RCI	SLOPE	MAXIMUM SPEED OBTAINED	TIME TO REACH 10 MPH	TIME TO REACH 20 MPH	TIME TO REACH 30 MPH	TIME TO REACH 40 MPH	TIME TO REACH 50 MPH
HMMWV W/M101	290	0.0	50.8	1.5	5.0	11.8	27.5	79.0
M151 W/M416	290	0.0	41.4	4.7	10.1	17.7	55.2	-
M561 W/M101	290	0.0	31.1	5.5	14.6	32.1	-	-
M151 W/AMMO TRL	290	0.0	43.6	4.0	8.4	14.2	33.9	-
M151A2	290	0.0	48.3	2.8	5.7	9.2	18.5	-
M561	290	0.0	38.7	4.4	10.4	20.7	-	-
HMMWV	290	0.0	58.0	1.2	3.5	7.6	15.4	29.7
HMMWV W/SHELTER	290	0.0	55.3	1.3	4.1	9.1	19.4	41.1

TABLE 13

SPEED VERSUS ELAPSED TIME AS A FUNCTION OF SOIL STRENGTH

VEHICLE	SURFACE RCI	SLOPE	MAXIMUM SPEED OBTAINED	TIME TO REACH 10 MPH	TIME TO REACH 20 MPH	TIME TO REACH 30 MPH	TIME TO REACH 40 MPH	TIME TO REACH 50 MPH
HMMWV W/M101	120	0.0	44.4	1.5	5.4	13.5	40.0	-
M151 W/M416	120	0.0	35.2	4.9	10.8	20.0	-	-
M561 W/M101	120	0.0	31.1	5.8	17.4	49.0	-	-
M151 W/AMMO TRL	120	0.0	38.6	4.1	8.8	15.8	-	-
M151A2	120	0.0	44.6	2.9	5.9	9.8	23.3	-
M561	120	0.0	31.1	4.5	11.4	24.9	-	-
HMMWV	120	0.0	53.3	1.2	3.7	8.2	18.0	42.4
HMMWV W/SHELTER	120	0.0	49.7	1.3	4.3	10.0	24.1	-

TABLE 14

SPEED VERSUS ELAPSED TIME AS A FUNCTION OF SOIL STRENGTH

VEHICLE	SURFACE RCI	SLOPE	MAXIMUM SPEED OBTAINED	TIME TO REACH 10 MPH	TIME TO REACH 20 MPH	TIME TO REACH 30 MPH	TIME TO REACH 40 MPH	TIME TO REACH 50 MPH
HMMWV W/M101	60	0.0	32.6	1.7	6.4	22.0	-	-
M151 W/M416	60	0.0	32.5	5.3	12.8	32.6	-	-
M561 W/M101	60	0.0	17.6	6.7	-	-	-	-
M151 W/AMMO TRL	60	0.0	32.4	4.5	10.1	21.7	-	-
M151A2	60	0.0	36.9	3.1	6.5	11.6	-	-
M561	60	0.0	30.2	5.2	15.7	60.0	-	-
HMMWV	60	0.0	42.9	1.3	4.1	10.2	34.8	-
HMMWV W/SHELTER	60	0.0	37.7	1.4	4.9	13.7	-	-

2.4 Acceleration and Speed on Slopes

The acceleration performance of the various vehicles in soils of three different strengths, RCI 290, 120 and 60[3], is presented in Tables 12-14. The RCI 290 soil is a strong soil, the RCI 120 has moderate strength and the RCI 60 is relatively weak. It can be seen by referring to the tables that the times to achieve a given speed increase as the soil strength decreases. In terms of highest speed achieved and times to reach a given speed, the HMMWV exhibited the best performance.

Profiles of acceleration performance over the various strength soils are presented in Appendix A.

A further measure of vehicle performance is the speeds it can attain on slopes of various grades. Tables 15-17 present the speeds attained by the various vehicles on grades ranging from 0 to 60 percent, on soil strengths of RCI 290, 120 and 60. Attention is directed to the comparative performance of the M151A2 and the HMMWV. Neither vehicle ascends the slopes at speeds consistently higher than the other. This may be explained by referring to Figure 1. In this plot, the ratio of the vehicle tractive force to vehicle weight is shown as a function of speed. It will be noted that the plots for this function cross at several points, indicating higher tractive force available to one or the other of the vehicles and consequently a greater speed on a given slope as shown in the tables.

2.5 Lateral Stability.

In the course of their operations, vehicles are often required to traverse side slopes. During this time, the vehicle may maneuver to change direction, avoid obstacles or for other reasons. When the maneuvering involves turning, centrifugal forces are developed. In addition to this there is a down hill force attributable to the inclination of the vehicle on the side slope. These two forces can act in concert to overturn the vehicle. The greatest potential to accomplish this occurs when the vehicle path on the slope is perpendicular to the maximum gradient of the slope and the radius of the turn circle lies along this gradient with its center uphill of the vehicle. Lateral instability can arise in two forms. First, if the resisting force of the soil is less than the sum of the two forces, sliding will occur. Secondly, if the overturning moments due to the forces are greater than the vehicle restoring moment, tipping or overturning will occur. All other things being equal, for a given vehicle, the overturning moments will vary directly as the vertical height of the center of gravity.

A means of determining the stability of a vehicle is to fix the side slope angle, turn radius and soil strength and then compute the speed at which

---

NOTE: [1]RCI (Rating Cone Index) is a rating of the soil strength under vehicular traffic.

TABLE 15
PREDICTED SPEED ON SLOPE PERFORMANCE (MPH)

		% SLOPE												
VEHICLE	RCI	0	5	10	15	20	25	30	35	40	45	50	55	60
HMMWV W/M101	290	51.3	31.5	24.1	18.0	14.5	11.6	9.4	7.6	5.5	1.1	-	-	-
M151 W/M416	290	40.2	31.6	19.3	16.6	9.6	9.3	9.1	7.4	-	-	-	-	-
M561 W/M101	290	31.2	17.6	15.7	8.1	7.7	7.0	5.5	3.8	3.3	2.8	-	-	-
M151 W/AMMO TRL	290	43.7	32.3	19.3	18.8	14.7	9.3	8.8	8.2	3.7	-	-	-	-
M151A2	290	48.4	34.1	32.2	19.4	19.2	16.5	12.3	9.4	9.2	9.0	8.8	6.8	3.7
M561	290	42.1	28.2	17.5	14.9	8.1	7.9	7.4	6.8	5.3	3.9	3.5	3.1	2.7
HMMWV	290	58.2	40.9	29.7	24.6	19.3	16.7	14.1	11.9	10.3	8.8	7.5	5.9	4.1
HMMWV W/SHELTER	290	55.5	36.3	27.1	21.7	17.5	14.6	12.1	10.3	8.7	7.2	5.8	4.7	2.3

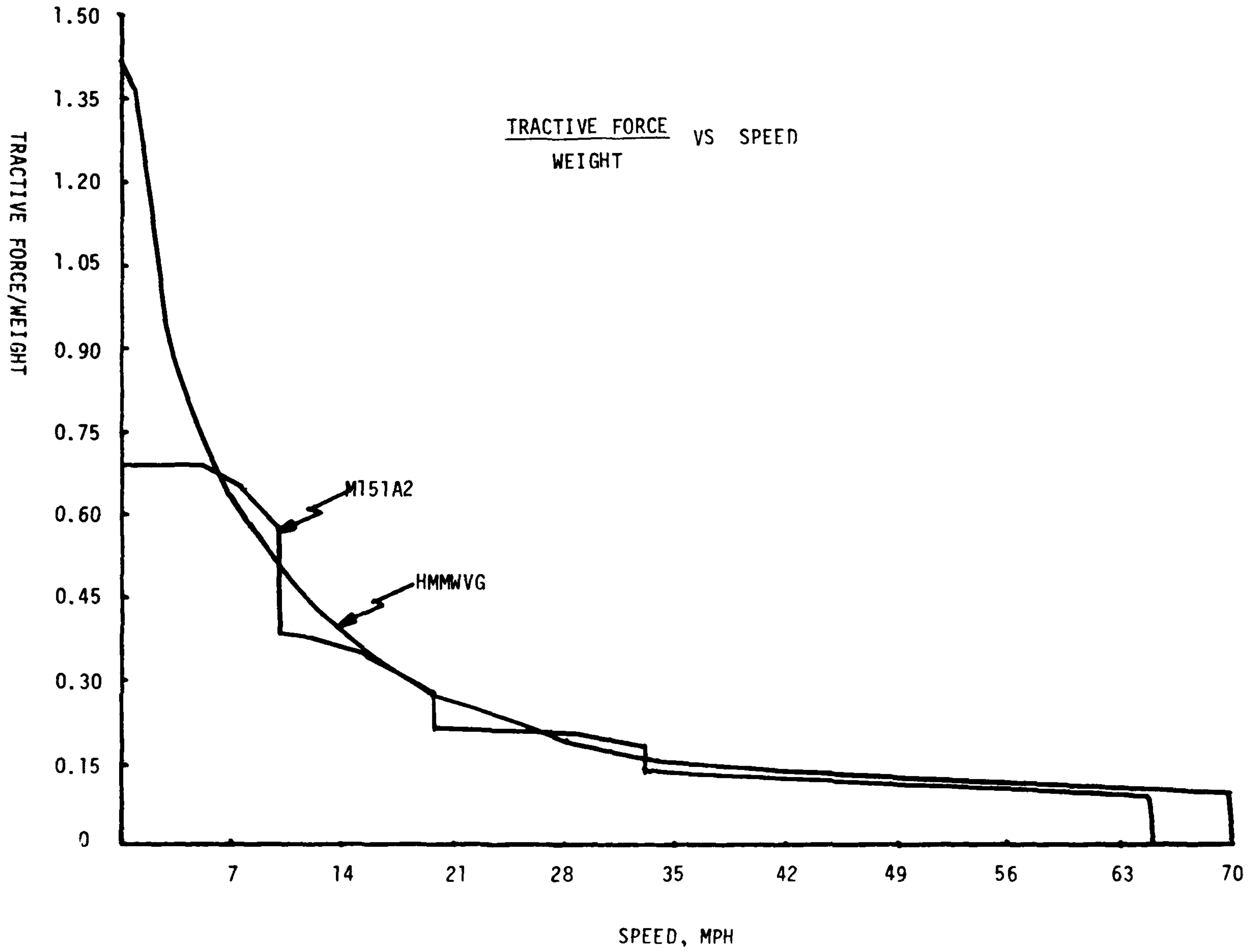
TABLE 16
PREDICTED SPEED ON SLOPE PERFORMANCE (MPH)

VEHICLE	RCI	% SLOPE 0	5	10	15	20	25	30	35	40	45	50	55	60
HMMWV W/M101	120	44.8	28.8	22.1	17.1	13.6	11.0	8.9	7.1	4.7	-	-	-	-
M151 W/M416	120	34.2	28.3	19.2	15.3	9.5	9.3	9.0	6.7	-	-	-	-	-
M561 W/M101	120	31.1	17.5	14.3	8.0	7.6	6.8	4.2	3.7	3.1	2.5	-	-	-
M151 W/AMMO TRL	120	38.6	32.2	19.2	17.7	12.9	9.1	8.6	8.0	1.1	-	-	-	-
M151A2	120	44.7	32.5	30.3	19.3	18.9	15.7	10.5	9.4	9.1	8.9	8.3	6.2	2.5
M561	120	31.2	24.5	17.4	14.2	8.1	7.8	7.3	6.6	4.2	3.8	3.3	2.9	2.5
HMMWV	120	53.4	36.6	27.8	23.4	18.6	16.0	13.5	11.5	9.9	8.5	7.1	5.4	3.3
HMMWV W/SHELTER	120	50.0	32.5	25.7	19.9	16.7	13.8	11.6	9.8	8.3	6.8	5.5	4.3	1.6

TABLE 17

PREDICTED SPEED ON SLOPE PERFORMANCE (MPH)

		% SLOPE												
VEHICLE	RCI	0	5	10	15	20	25	30	35	40	45	50	55	60
HMMWV W/M101	60	32.5	24.7	18.4	14.9	11.9	9.6	7.8	5.5	-	-	-	-	-
M151 W/M416	60	32.3	19.3	17.2	10.6	9.3	9.0	7.7	4.0	-	-	-	-	-
M561 W/M101	60	17.6	16.4	8.1	7.8	7.1	5.9	3.4	2.1	0.8	-	-	-	-
M151 W/AMMO TRL	60	31.9	22.0	18.2	14.0	2.5	-	-	-	-	-	-	-	-
M151A2	60	37.0	32.3	21.2	19.1	17.2	13.5	9.4	9.2	8.9	8.7	6.9	3.3	-
M561	60	30.3	17.5	15.8	8.7	8.0	7.5	6.8	5.8	3.7	2.7	1.7	0.7	-
HMMWV	60	43.0	30.6	25.1	19.9	17.0	14.4	12.1	10.5	8.9	7.5	5.9	2.1	-
HMMWV W/SHELTER	60	37.9	27.5	22.3	17.7	14.8	12.2	10.4	8.8	7.3	5.8	4.5	2.2	-



TRACTIVE FORCE / WEIGHT VS SPEED
TRACTIVE FORCE/WEIGHT
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0
7
14
21
28
35
42
49
56
63
70
M151A2
HMMWVG
SPEED, MPH

FIGURE 1

the vehicle will slide and the speed at which it will overturn. Of course, the speeds thus derived will hold only for the set of fixed conditions imposed and will vary as the conditions vary. Table 18 presents sliding and tipping speeds for several sets of conditions. The soil strength selected was RCI 120, a medium strength soil. The turning circle radius chosen represents the minimum turn radius of each vehicle. Sliding and tipping speeds were calculated for the slopes indicated in the tables. Two versions of the M561 are shown, one mounting a 2500 pound S250 shelter and one a 3600 pound shelter of the same category. The HMMWV mounts the 3600 pound S250 shelter.

All the vehicles shown have tipping speeds that are higher than the sliding speeds, hence sliding will occur. The M561 is an articulated vehicle and speeds are presented for both sections of the vehicle. It should be noted that the tipping speeds of the two units differ. If the second unit overturns before the first, the whole vehicle will be immobilized, hence the tipping speeds of the second unit apply to the whole vehicle. Since both the HMMWV and the M561 carrying the S250 shelter at 3600 pounds have the same turning circle, we may compare their tipping speeds. On any given slope, the overturning speed of the HMMWV is higher than that of the M561, indicating a greater margin of stability.

3. AIR TRANSPORTABILITY

Although the vehicles, aircraft and scenarios to be considered are specified in Section 1, there are additional conditions which affect the evaluation. They are:

a. The term "density altitude" as used in the study request was replaced by "pressure altitude" as agreed during a telephone conversation between USAIS and this office.

b. There was no data base available which contained the distribution of pressure altitude/temperature conditions for either Europe or the Mid-East. Existing information on this subject indicates that 2000'/70°F is a suitable approximation for Europe while 4000'/95°F may be used for Mid-East scenarios.

c. The round trip distances for helicopter missions are taken to be 104 miles for Europe and 198 miles for the Mid-East. These distances which were agreed to at the beginning of this study, are representative of those encountered between points of debarkation and engagement in Europe and the Mid-East.

Physical Characteristics used to determine vehicle air transportability are presented in Table 19.

3.1 Fixed Wing Transport.

Analysis of fixed wing transportability was based on homogeneously loading as many of each system type as possible into the aircraft of interest. Consideration was given to the system's total weight, total length and center of

TABLE 18

LATERAL STABILITY

VEHICLE	RCI	% SLOPE	TURNING CIRCLE RADIUS (FT)	SPEED AT SLIDE (MPH)	SPEED AT TIPPING (MPH)
HMMWV 2500#	120	0	30	16.9	22.6
		20		14.6	21.1
		30		12.6	19.8
		40		10.2	18.4
HMMWV/ SHELTER 3600#	120	0	30	16.9	20.1
		20		14.6	18.6
		30		12.6	17.2
		40		10.2	15.7
M561 1st UNIT 2500# SHELTER	120	0	30	16.8	24.3
		20		14.6	23.4
		30		12.6	22.2
		40		10.2	20.9
M561 2nd UNIT 2500# SHELTER	120	0	30	16.8	19.1
		20		14.6	17.5
		30		12.6	16.0
		40		10.2	14.3

LATERAL STABILITY

VEHICLE	RCI	% SLOPE	TURNING CIRCLE RADIUS (FT)	SPEED AT SLIDE (MPH)	SPEED AT TIPPING (MPH)
M561 1st UNIT 3600# SHELTER	120	0	30	16.8	24.3
		20		14.6	23.4
		30		12.6	22.2
		40		10.2	20.9
M561 2nd UNIT 3600# SHELTER	120	0	30	16.8	18.4
		20		14.6	16.6
		30		12.6	15.0
		40		10.2	13.3
M151A2	120	0	17	12.7	16.6
		20		11.0	15.8
		30		9.5	14.8
		40		7.7	13.7

TABLE 19

VEHICLE PHYSICAL CHARACTERISTICS

CHARACTERISTIC	VEHICLE M151	M151 W/ M416	2-M151 W/M416	M561	HMMWV
WEIGHT (LB)	3600	4790	8570	10,300	7500
LENGTH (IN)	132.7	235.7	368.4	230	190
WIDTH (IN)	64.0	64.0	64.0	84.4	85
HEIGHT (IN)	52.5	52.5	52.5	67.8	72
LONGITUDINAL C.G. LOCATION	58.0 in REAR OF FRONT BUMPER	99.8 in REAR OF FRONT BUMPER	N/A	113.0 in REAR OF FRONT BUMPER	101 in REAR OF FRONT BUMPER

gravity (c.g.) location with respect to the optimum aircraft c.g. position. Analysis results are presented in Table 20.

The limiting parameter for those systems considered was the overall length of each vehicle or vehicle combination.

It should be noted that while the C-5A aircraft was included in the analysis, its availability to carry these vehicles would be limited. In no case is that aircraft's maximum payload limit challenged by these systems. Normally, the C-5A is reserved for high priority systems such as the M-1 and M-2 which do challenge that parameter.

3.2 Rotary Wing Transport.

Complete payload vs range curves for the CH-47C and D helicopters and the UH-60 and UH-60(BI) helicopters are presented in Appendix B. Data from these curves are summarized in Table 21.

The four air vehicle systems analyzed met round trip mission distance requirements with the following exceptions:

a. The 3-piece system consisting of the two M151 trucks and M416 trailer cannot be transported by the UH-60 helicopters because there are no provisions for slinging three vehicles, and even if there were, the system's total weight would limit the round trip flying distance to less than mission requirements for either scenario.

b. The M561 cannot be transported by the UH-60 series because its weight exceeds the craft's maximum payload capacity.

c. Mission requirements in either scenario were not met by the UH-60 when carrying the HMMWV. When the UH-60 (BI) transports the HMMWV, it can meet mission requirements in Europe only. It should be noted that this aircraft exists only as a concept and its performance when fielded may vary considerably from that postulated herein.

4. CONCLUSIONS

When the HMMWV is compared to the M151 and the M561 baseline vehicle in off-road travel, its performance generally exceeds that of the latter two vehicles. The HMMWV carrying a 3600 pound S250 shelter shows little or no reduction in performance when compared to the HMMWV at its rated cargo payload of 2500 pounds. All of the vehicles exhibited a degradation in performance when trailers were towed by them.

The on-road speeds of the HMMWV generally exceeded those of the M151 and the M561, often by an appreciable amount.

TABLE 20

MAXIMUM SYSTEMS CARRIED

SYSTEM	C-130	C-141B	C-5A
M561	2	5	12
M151	4	8	20
2-M151 + M416	1	3	8
HMMWV	2	5	14

TABLE 21

HELICOPTER TRANSPORTABILITY

	MAXIMUM ROUNDTRIP CAPABILITY - NAUTICAL MILES			
HELICOPTER	M151	2-M151/M416	M561	HMMWV
CH-47C	240[a]	240[c]	240[e]	240[e]
CH-47D	260[a]	280[c]	260[e]	260[e]
UH-60	200[b]	0[d]	0[f]	b,g
UH-60 (BI)	240[b]	0[d]	0[f]	b,h

NOTES:
[a] Two vehicles carried internally plus one vehicle slung externally.
[b] One vehicle slung externally.
[c] One system carried internally.
[d] No provisions for carrying three vehicle system.
[e] Can be carried internally or slung externally.
[f] Exceeds maximum payload capacity of helicopter.
[g] 0 (4000', 95°F), 50 miles (2000', 70°F), 162 miles (sea level, 59°F).
[h] 72 miles (4000', 95°F), 170 miles (2000', 70°F), 224 miles (sea level, 59°F)

Considered in the context of the various tactical mobility levels, the HMMWV displayed consistent superiority over the baseline vehicles.

The acceleration of the HMMWV was better than that of the baseline vehicles. The HMMWV generally met or exceeded the slope climbing performance of the other two vehicles.

In a comparison of the lateral stability of the HMMWV with the M561 with each carrying S250 shelter, the HMMWV was found to have the more stable configuration.

The HMMWV can be air transported by the C130, C141 and C5A in varying numbers. The UH-60 helicopter was not able to carry it over the distances required in the European and Mid-East scenarios.

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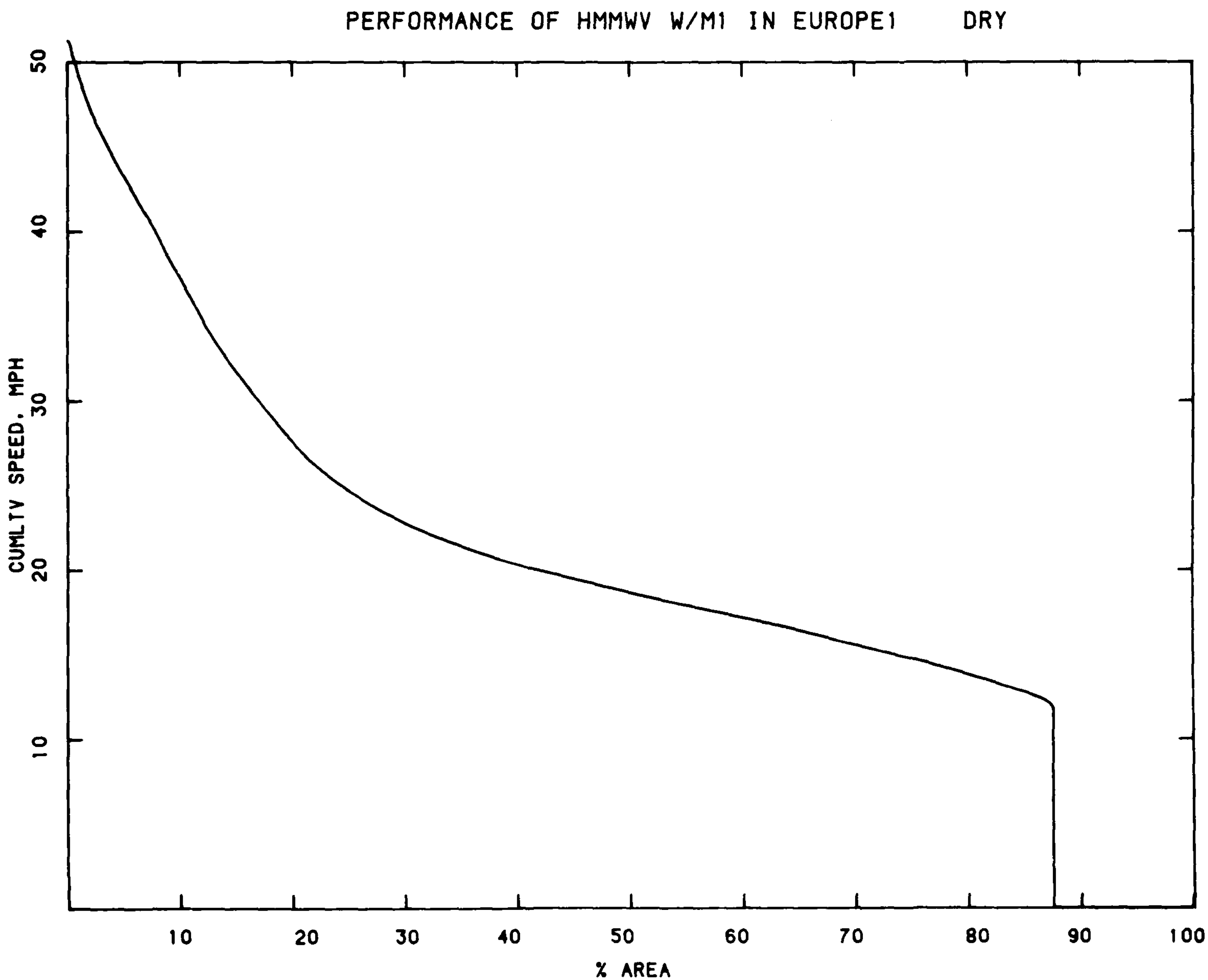
APPENDIX A

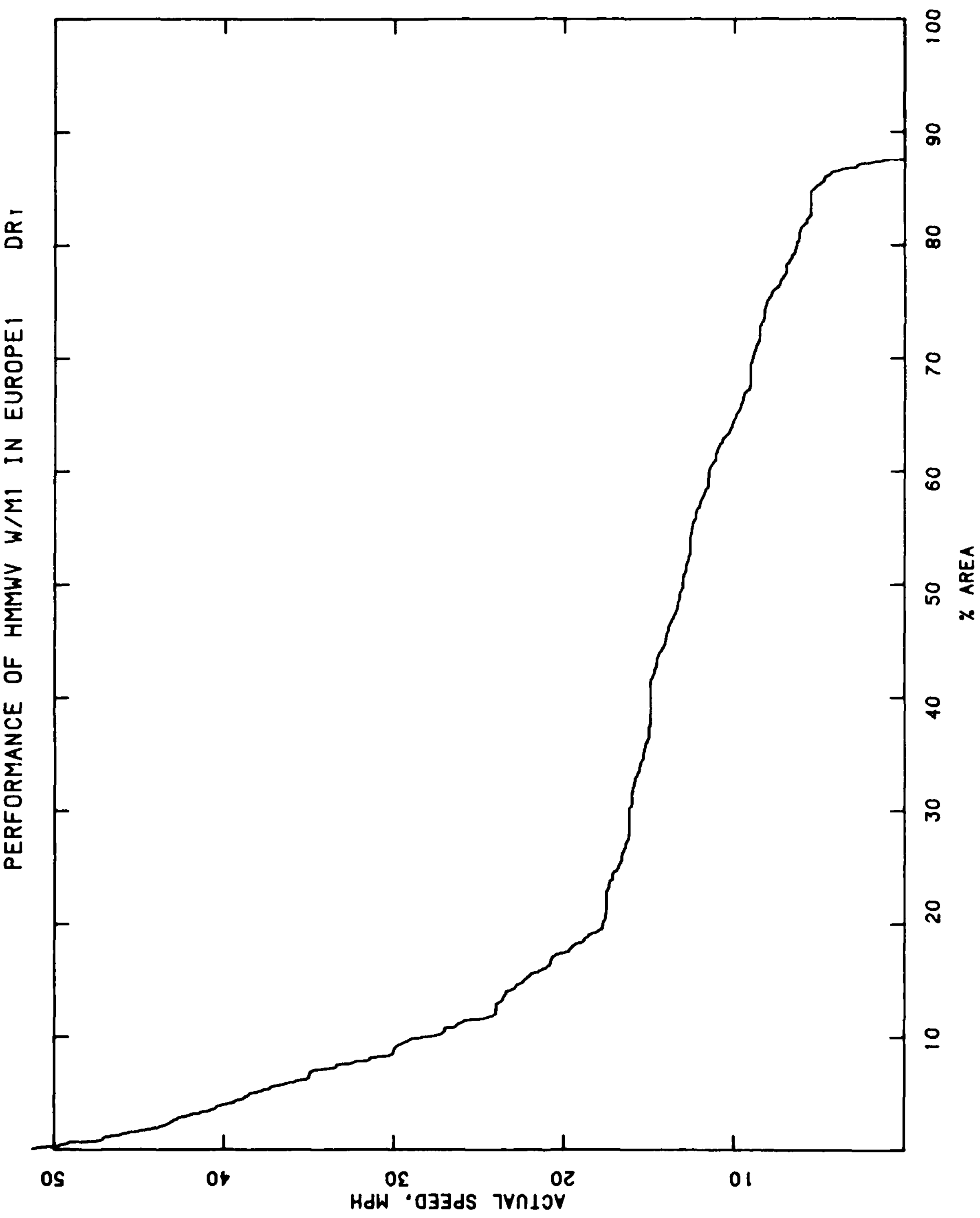
HMMWV Generic (HMMWVG) Vehicle Characteristics

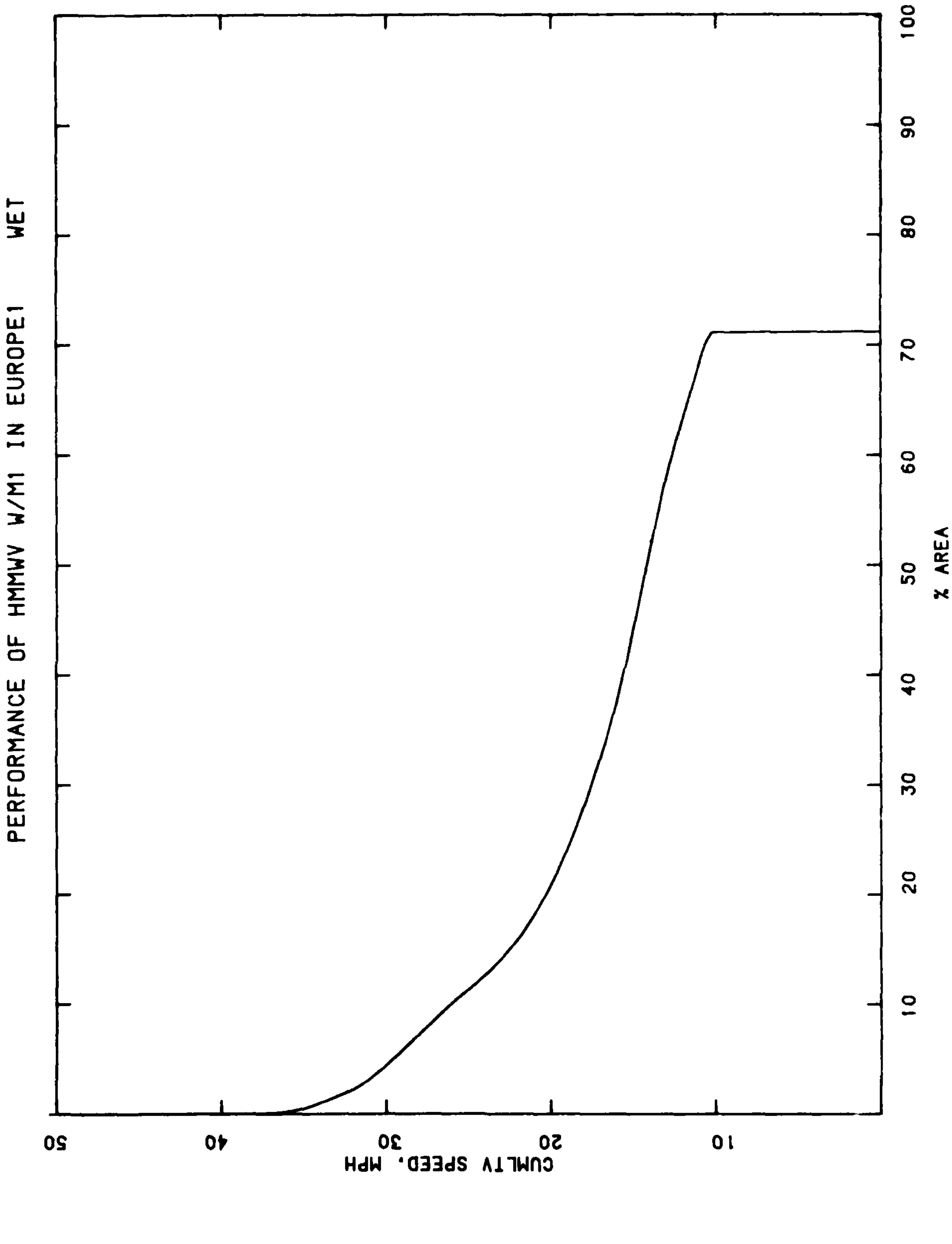
The HMMWV vehicle data presented on pages 41 and 42 represent characteristics derived from the vehicles in the HMMWV competition. These characteristics are representative of all the competition vehicles and yet are peculiar to none. The data shown are a complete set of those required as input to the Army Mobility Model.

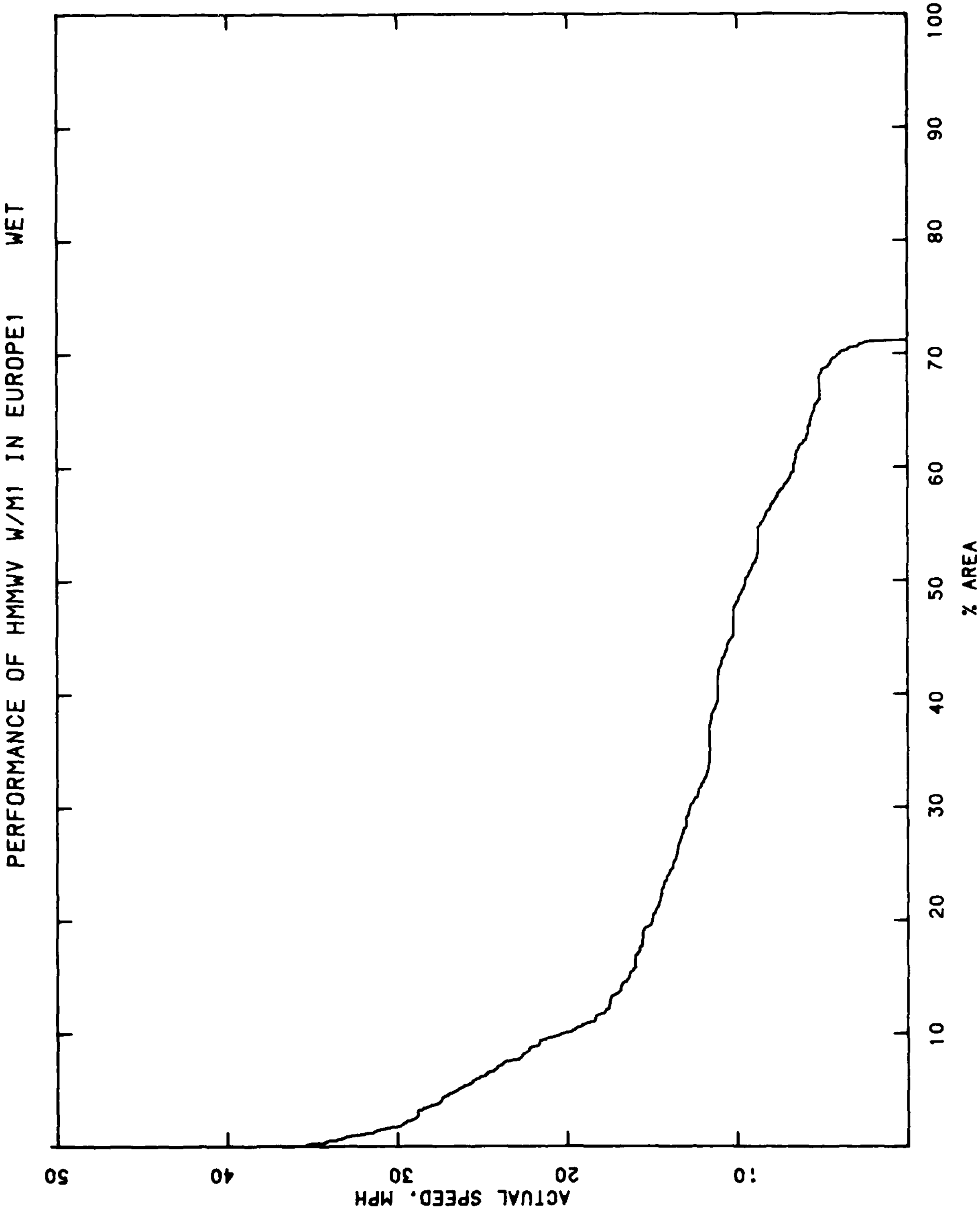
```
VEHICLE DATA FOR HMMWVG
***************************************************
.INDIVIDUAL VARIABLE LISTING
 * * * * * * * * * * * * * * * * * *
VD=       1.000      0 IF VEHICLE TRACKED,1 IF WHEELED
W=     7750.000      VEHICLE WEIGHT(LBS)
ALX=       .500      MAXAXLE LOAD/WT.IF WHEELS;C IF TRAX
WP=     7750.00      WT. ON PULLING AXLES IF WHEELED,0 IF  TRAX
NVEH=        1       VEHICLE TYPE (0=TRACKED,1=4X4,2=6X6, 3=8X8)
VL=     190.000      VEHICLE LENGTH(INCHES)
WV=      85.000      VEHICLE WIDTH(INCHES)
HP=      23.000      HEIGHT OF PUSHBAR(INCHES)
HB=      21.000      FRONT END CLEARANCE(INCHES)
GCX=     12.000      MINIMUM  GROUND CLEARANCE(INCHES)
DS=      17.000      IF TRAX,HORIZ.DIST. CG. TO FRONT ROAD WHEEL CL., IF WHEELE
                     ROLLING RADIUS(INCHES)
GC=      16.000      GROUND CLEARANCE AT CENTER OF GREATEST SPAN; IF TRAX,=10CC
TL=     132.000      DIST.FIRST TO LAST WHEEL/ROADWHEEL CL .
DWX=    132.000      IF TRAX=0,IF WHEELED MAX.DIST.BETWEEN ADJACENT WHEEL
                     CENTERLINES
AV=      65.000      APPROACH ANGLE(DEGREES)
ACG=     17.800      ANGLE BETWEEN LINE // TO GROUND AND   LINE BETWEEN CG. AND
                     CENTER OF REAR ROADWHEEL OR IDLER
FLEW=  11625.000     MAX.  FORCE LEADING EDGE WILL STAND(LBS )
XTW=     12.500      TIRE WIDTH(INCH)
XRDT=    16.500      RIM DIAMETER(INCH)
XWD=     37.000      OUTSIDE DIAMETER OF THE TIRE(INCH)
RR=      17.000      ROLLING RADIUS OF TIRE(INCH)
XTP=     17.000      TIRE PRESSURE(PSI)
XNT=      4.000      NUMBER OF WHEELS(DUALS AS ONE)
XNTE=     4.000      NUMBER OF WHEELS(DUALS AS TWO)
TPR=      4.000      TIRE PLY RATING
XCF=      0.000      0 WITH NO TIRE CHAINS,1 WITH TIRE  CHAINS
XNA=      2.000      NUMBER OF AXLES
RADIAL=     0        0 IF NO RADIALS,1 IF RADIALS
DRISCG=    56.100    HORZ. DIST. CG. TO CENTER OF REAR WHE EL
XBC=        .670     VEH.BRAKING FORCE/VEH.WEIGHT
TCMCGH=    18.000    VERT.DIST.CG.TO ROADWHEEL CL(INCH)
TCMCGF=    76.000    HORZ.DIST.CG.TO FRONT ROADWHEEL CL  (ICH)
TCMREC=    26.000    REAR END CLEARANCE(INCH)
TCMVDA=    45.000    VEH.DEPARTURE ANGLE(DEGREES)
TCMRWW=    17.000    IF TRAX RADIUS OF WHEEL/SPROCKET/IDLER USED TO DETERMINE
                     DEPARTURE ANGLE+TRACK THICKNESS.IF WHEELED,ROLL.RADIUS(IN)
TVAR=      0.000     1=MANUAL TRANS,-1=MANUAL/TRANSFER CASE,0=AUTOMATIC
EFF=       1.000     TRANSMISSION EFFICIENCY
FDR=       1.000     FINAL DRIVE RATIO
FDREF=      1.000    FINAL DRIVE EFFICIENCY
HPT=      20.000     HORSEPOWER/TON
RR=       17.000     TRAX=SPOCKET PITCH RADIUS(IN),WHEELS= TIRE ROLLING RADIUS
NN=         21       NUMBER OF POINTS IN TRACTIVE FORCE ARRAY
```

TRACTIVE FORCE ARRAY		OBSTACLE HEIGHT ARRAY		RMS ARRAY	
SPEED,MPH	T. FORCE, LBS.	OBST. HT.,INS	SPEED,MPH	RMS,INS	SPEED,MPH
0.000	10900.000	0.000	100.000	0.000	80.000
1.000	10500.000	4.000	100.000	.400	80.000
2.000	9000.000	4.500	70.000	.500	55.000
3.000	7250.000	5.000	45.000	.600	45.000
4.000	6400.000	6.000	27.500	.700	40.000
5.000	5750.000	7.000	19.500	.800	35.000
6.000	5250.000	8.000	14.500	.900	30.000
7.000	4800.000	9.000	11.000	1.000	27.000
8.000	4500.000	10.000	8.000	1.100	24.000
9.000	4200.000	11.000	6.000	1.200	22.000
10.000	3850.000	12.000	4.500	1.300	19.500
13.000	3100.000	13.000	3.500	1.400	17.500
15.000	2750.000	14.000	3.000	1.500	16.000
20.000	2000.000	30.000	2.000	1.800	13.000
24.000	1750.000	0.000	0.000	2.000	11.500
28.000	1400.000	0.000	0.000	2.500	9.500
34.000	1100.000	0.000	0.000	3.000	8.500
43.000	950.000	0.000	0.000	3.500	8.000
60.000	750.000	0.000	0.000	4.000	7.500
70.000	650.000	0.000	0.000	5.000	7.000
70.100	0.000	0.000	0.000	8.000	2.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000


PERFORMANCE OF HMMWV W/M1 IN EUROPE1 DRY
CUMLTV SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF HMMWV W/M1 IN EUROPE1 DRY
ACTUAL SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF HMMWV W/M1 IN EUROPE1 WET
CUMLTV SPEED, MPH
% AREA
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF HMMWV W/M1 IN EUROPE1 WET
ACTUAL SPEED, MPH
% AREA
50
40
30
20
10
10
20
30
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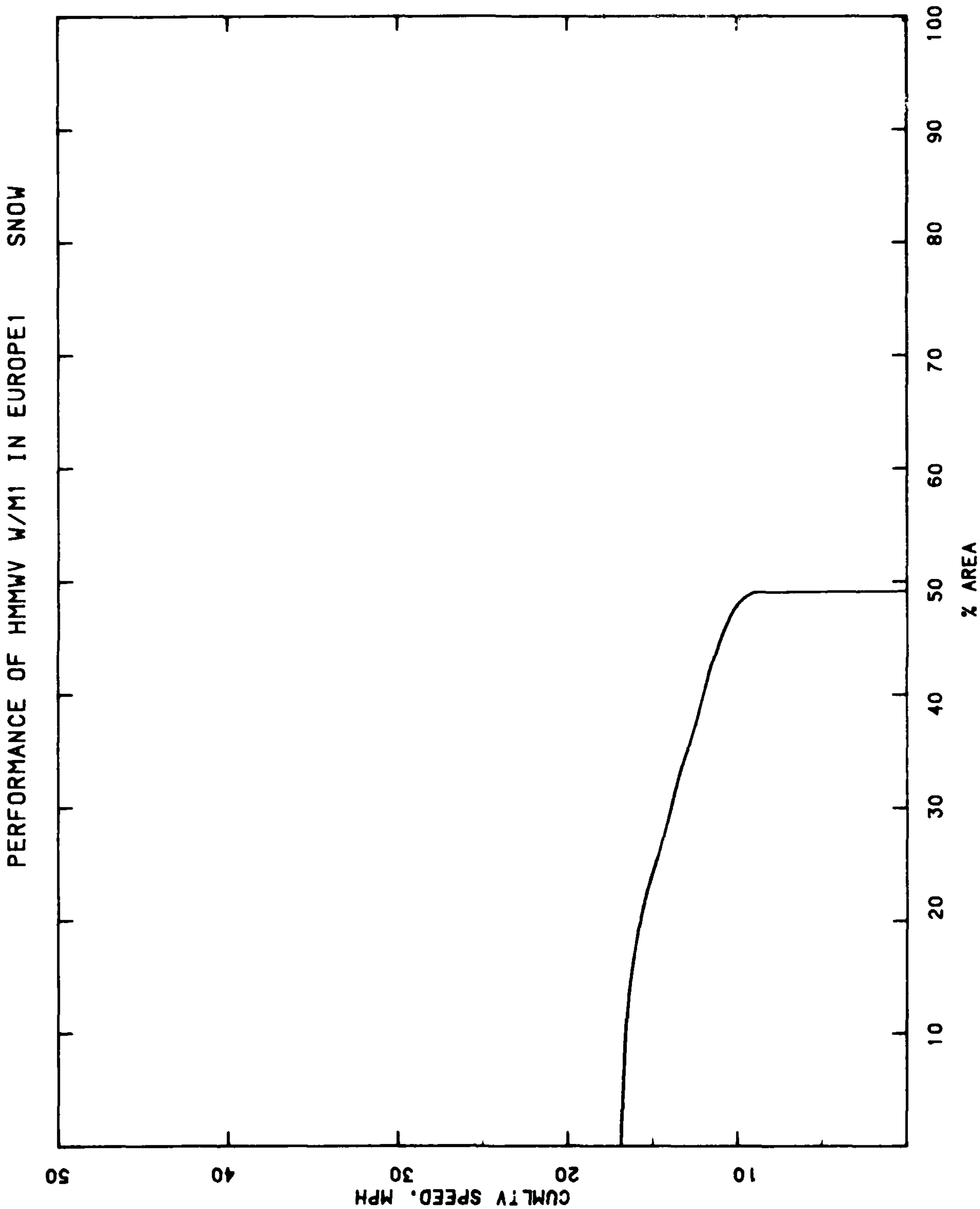
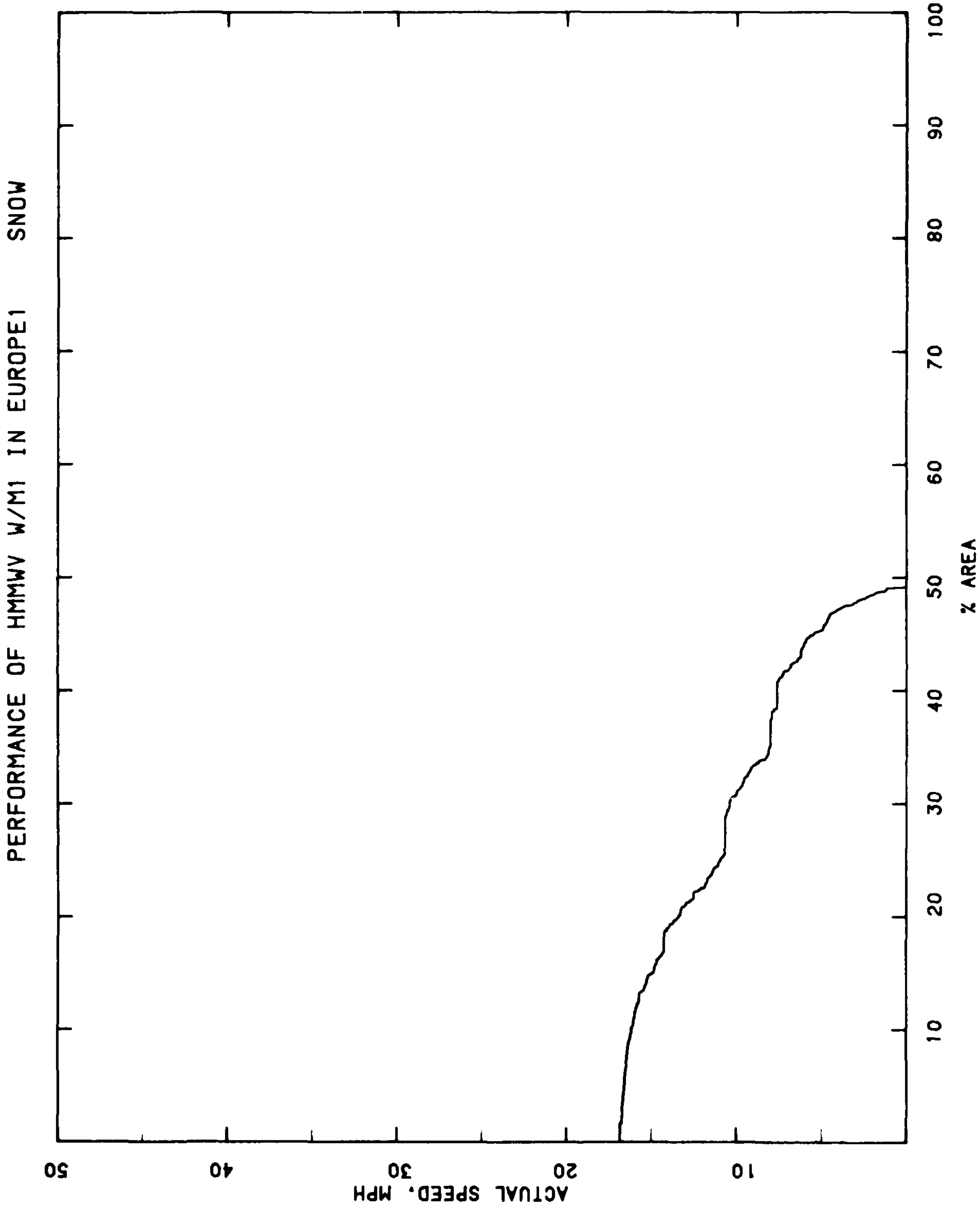
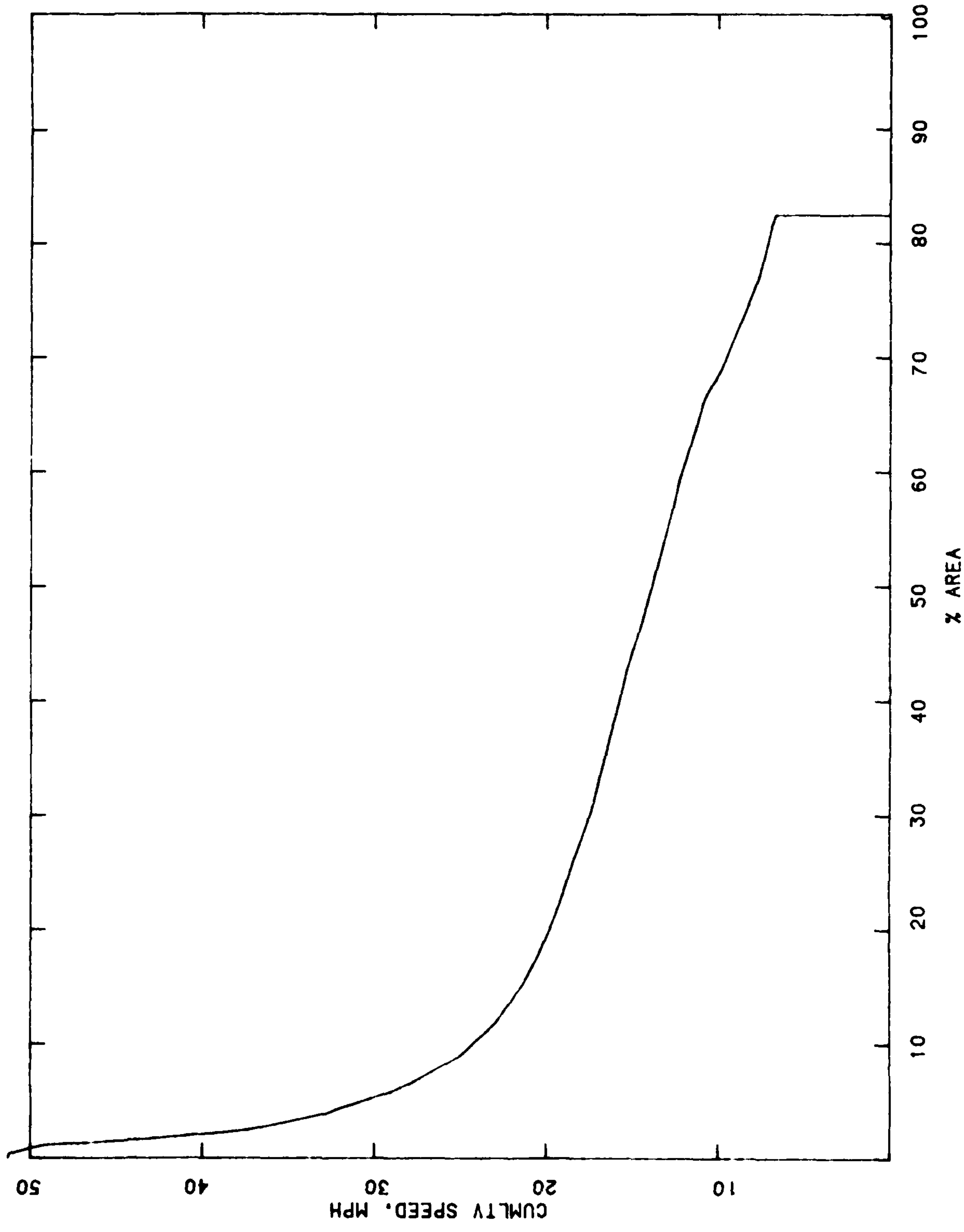
50
60
70
80
90
100



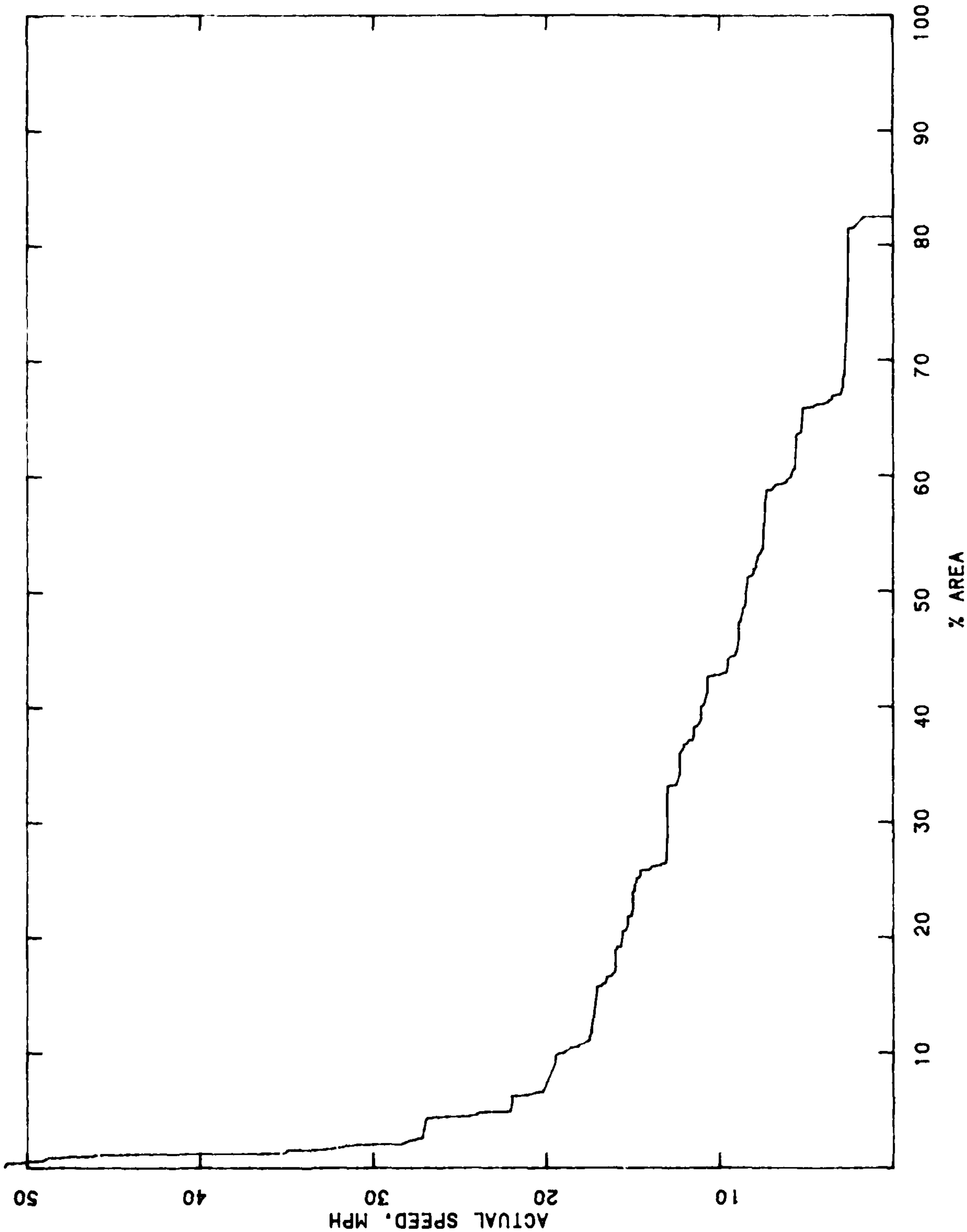
PERFORMANCE OF HMMWV W/M1 IN EUROPE1 SNOW
% AREA
10
20
30
40
50
60
70
80
90
100
CUMLTV SPEED, MPH
10
20
30
40
50

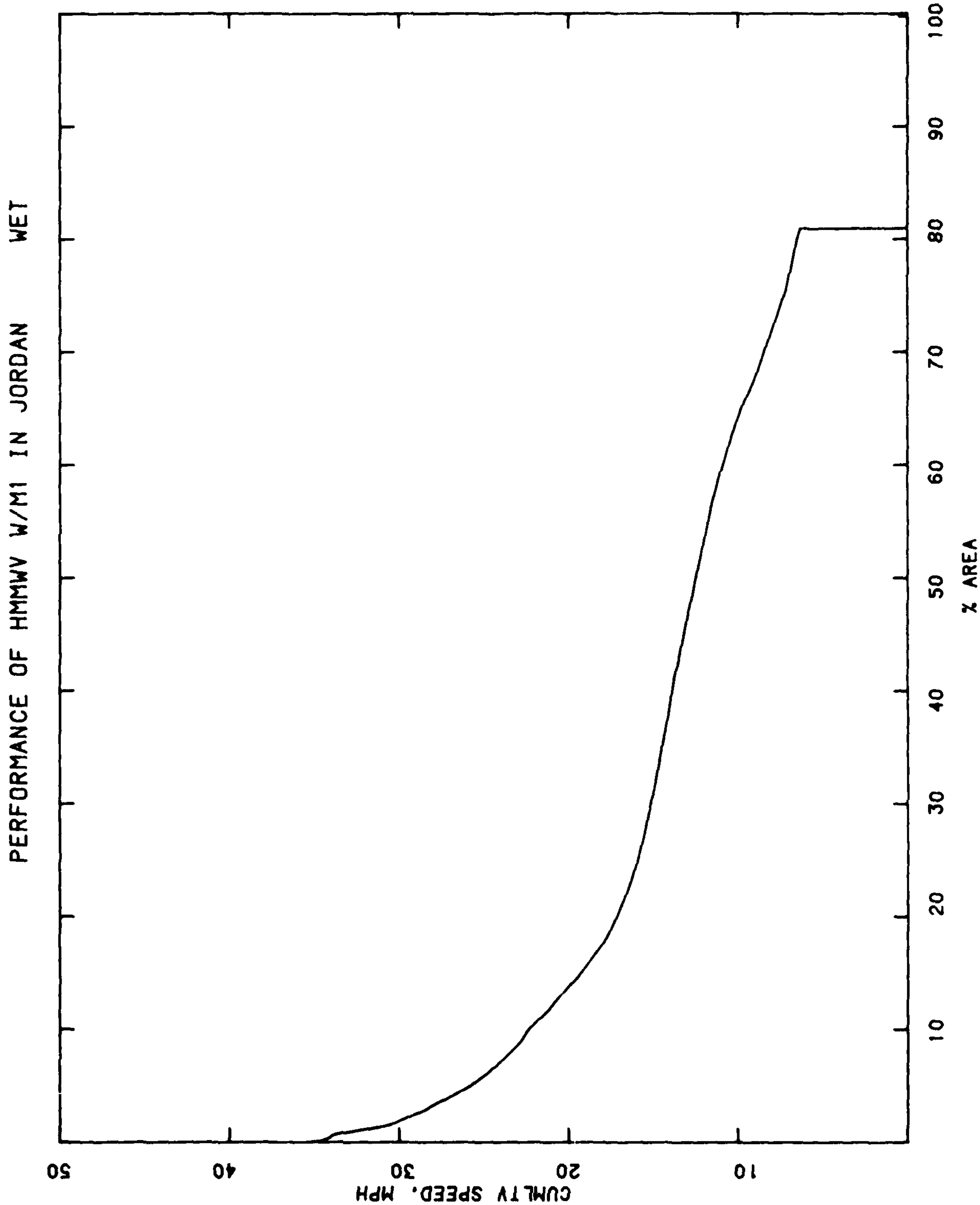

PERFORMANCE OF HMMWV W/M1 IN EUROPE1 SNOW
ACTUAL SPEED, MPH
% AREA
50
40
30
20
10
100
90
80
70
60
50
40
30
20
10

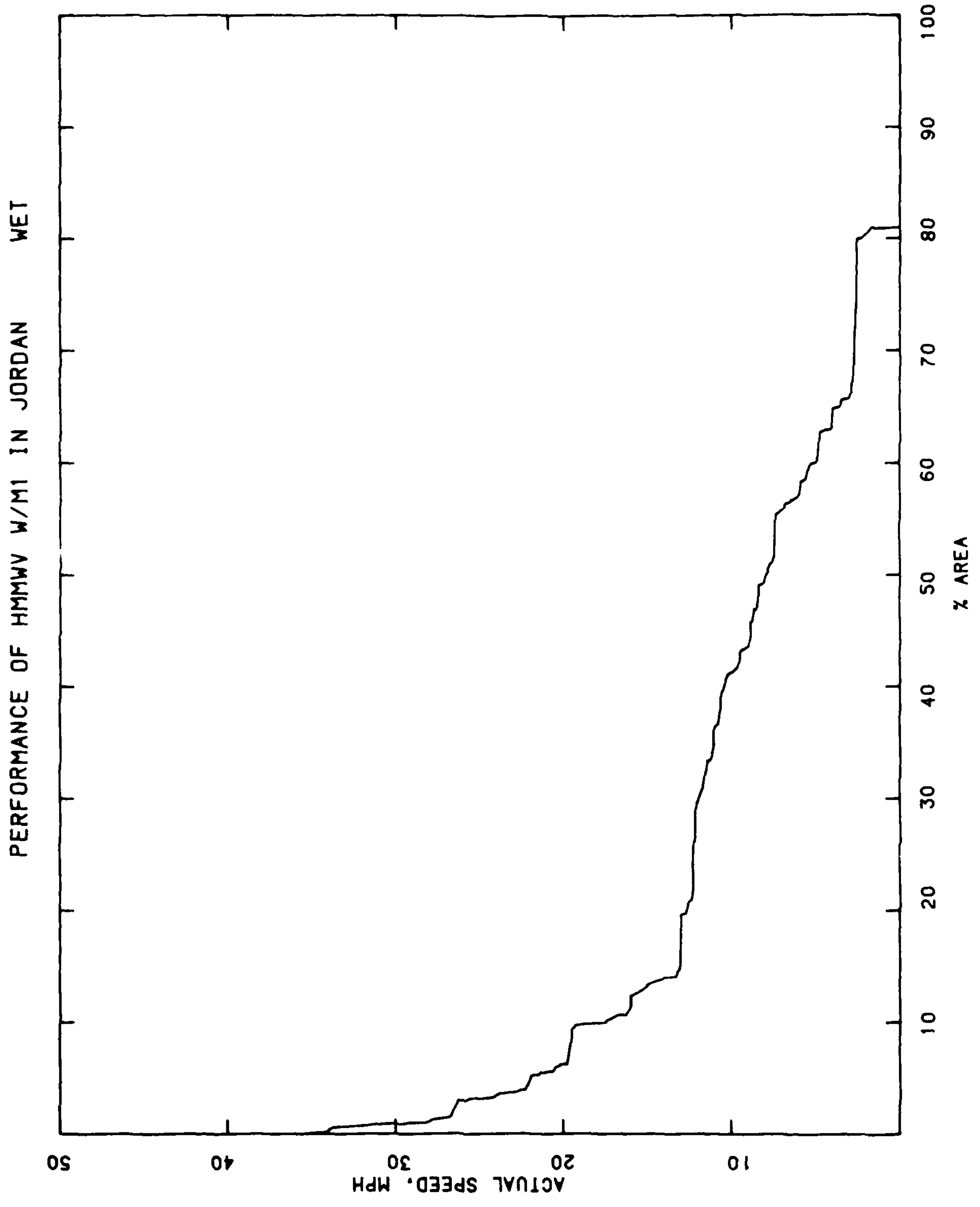
PERFORMANCE OF HMMWV W/M1 IN JORDAN DRY



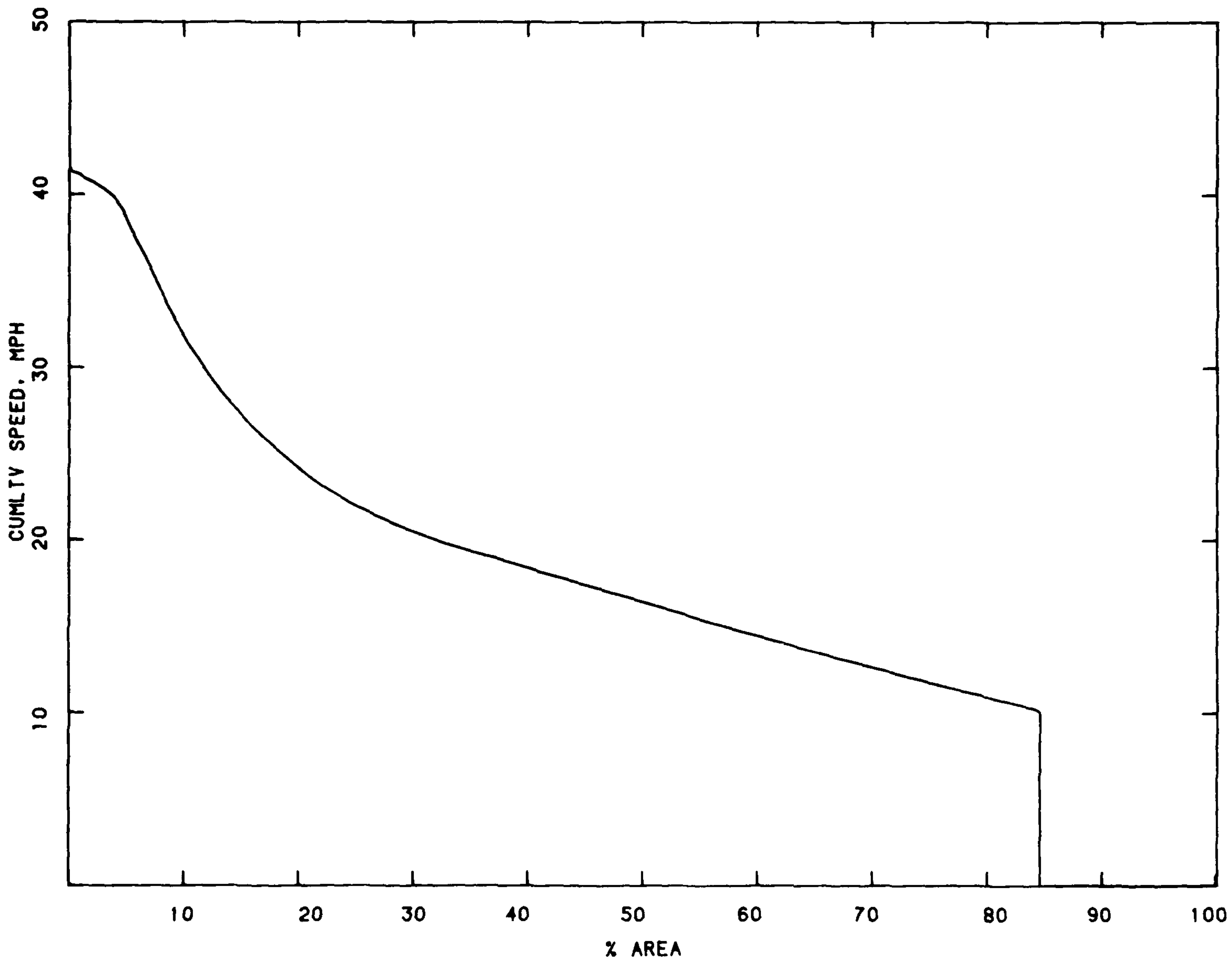
PERFORMANCE OF HMMWV W/M1 IN JORDAN DRY

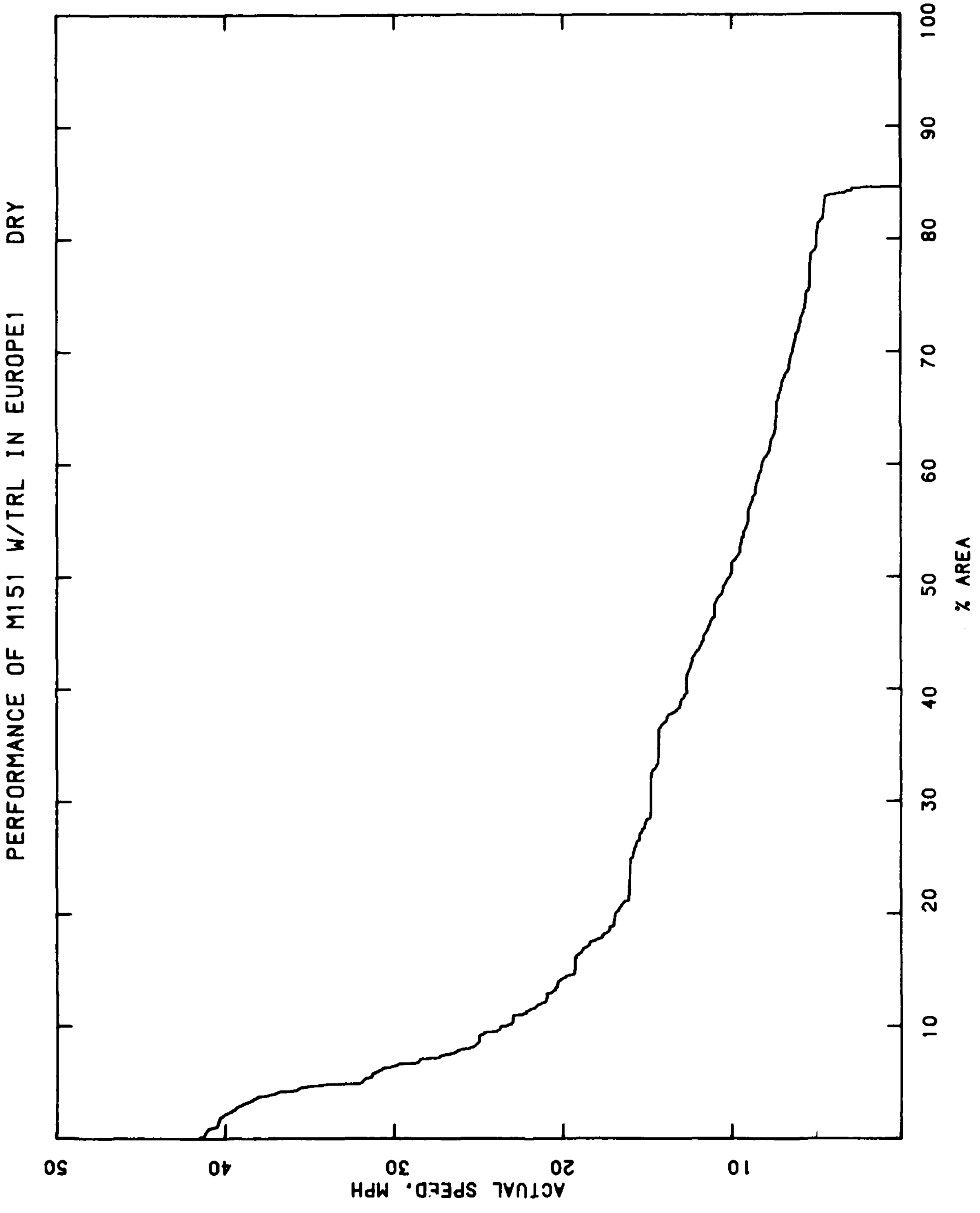



PERFORMANCE OF HMMWV W/M1 IN JORDAN WET
CUMLTV SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100

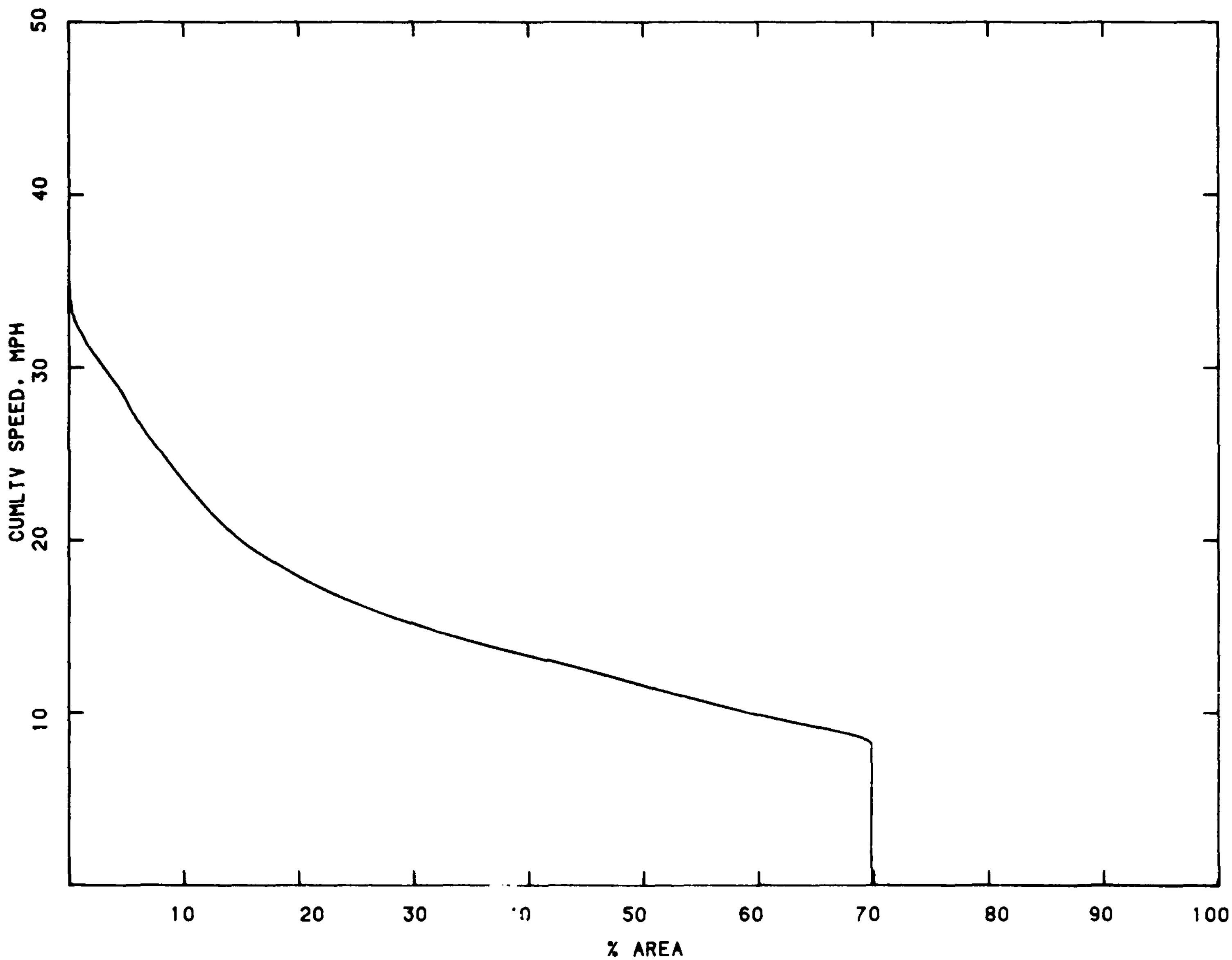

PERFORMANCE OF HMMWV W/M1 IN JORDAN WET
ACTUAL SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100

PERFORMANCE OF M151 W/TRL IN EUROPE1 DRY

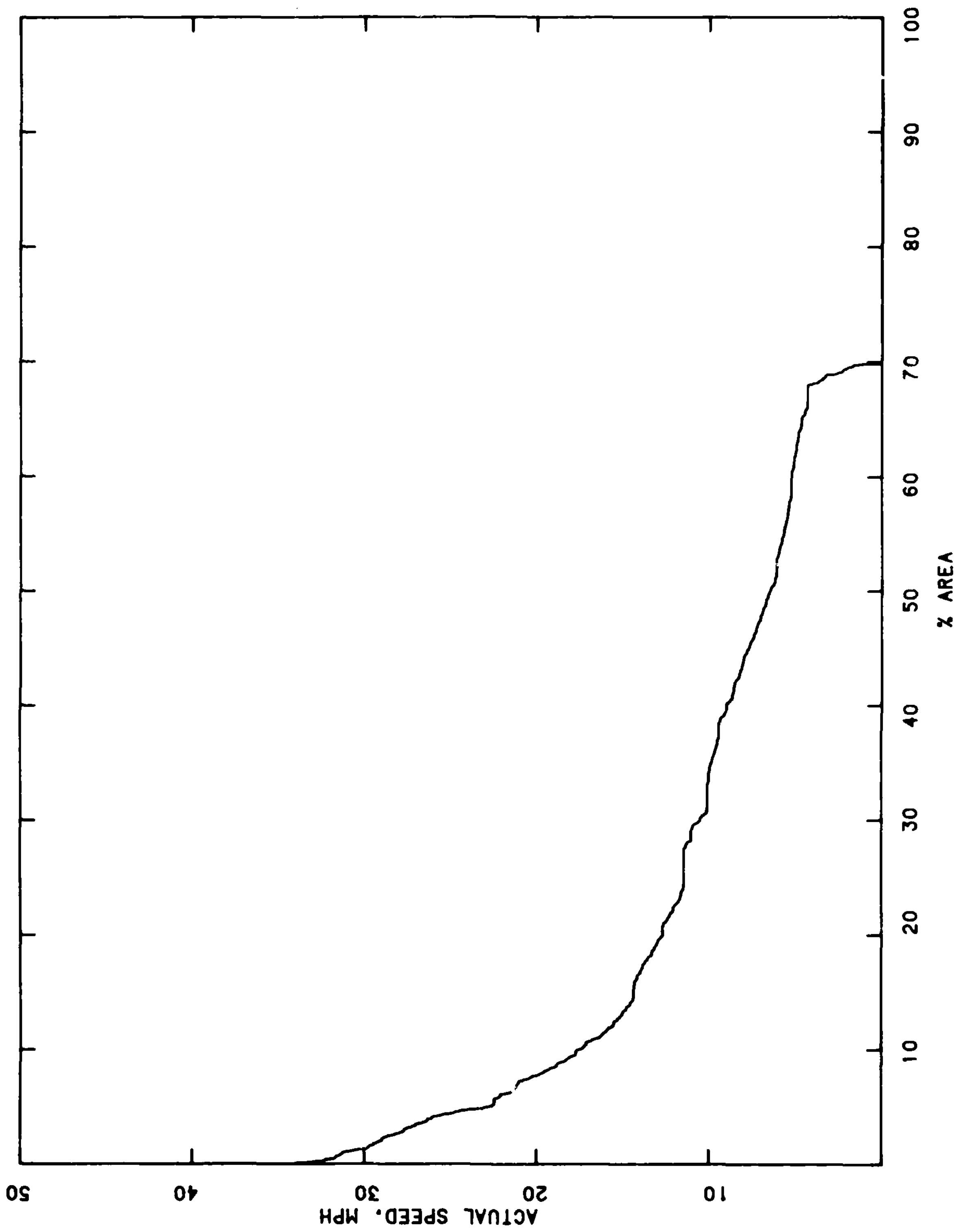



PERFORMANCE OF M151 W/TRL IN EUROPE1 DRY
ACTUAL SPEED, MPH
% AREA
50
40
30
20
10
100
90
80
70
60
50
40
30
20
10

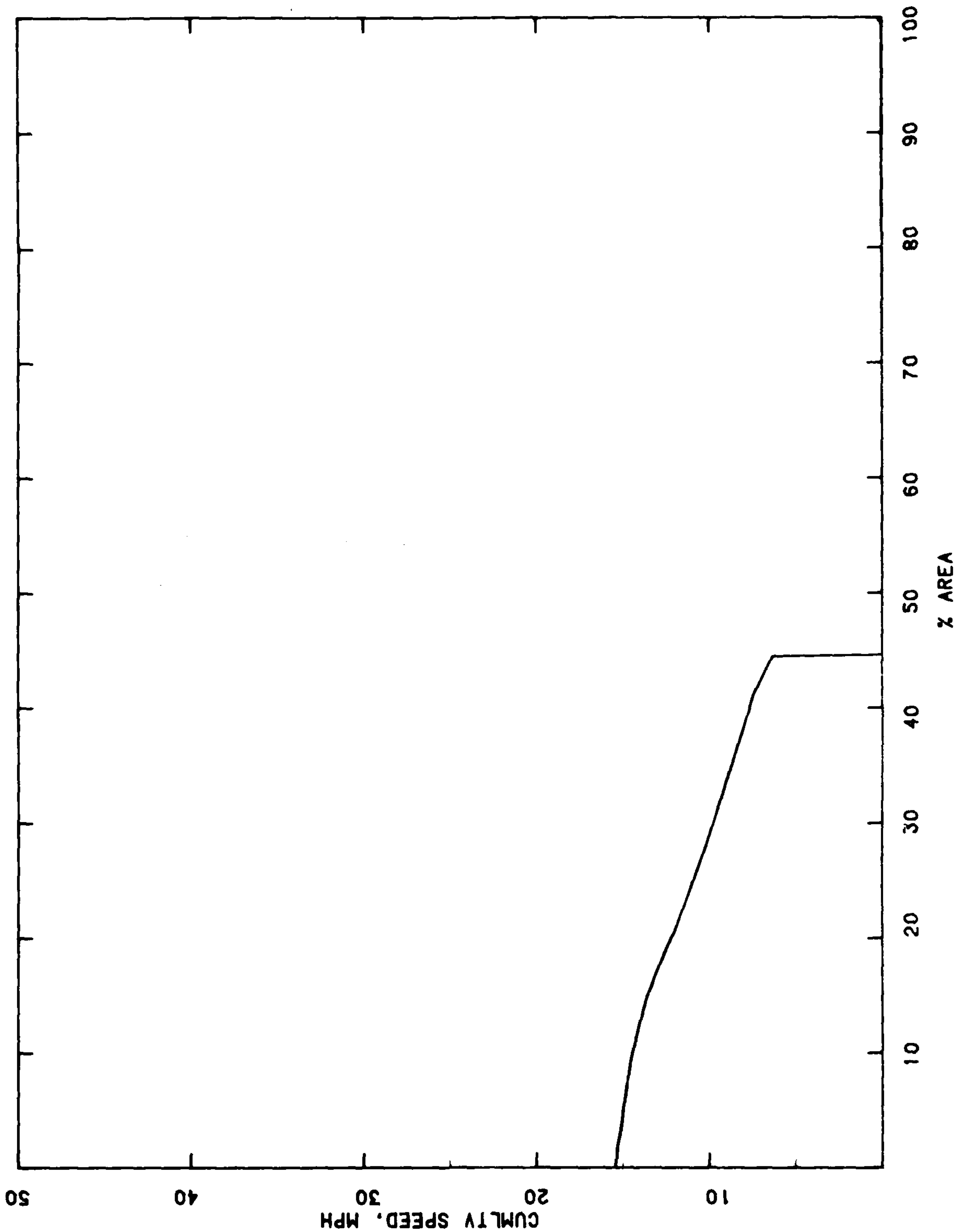
PERFORMANCE OF M151 W/TRL IN EUROPE1 WET

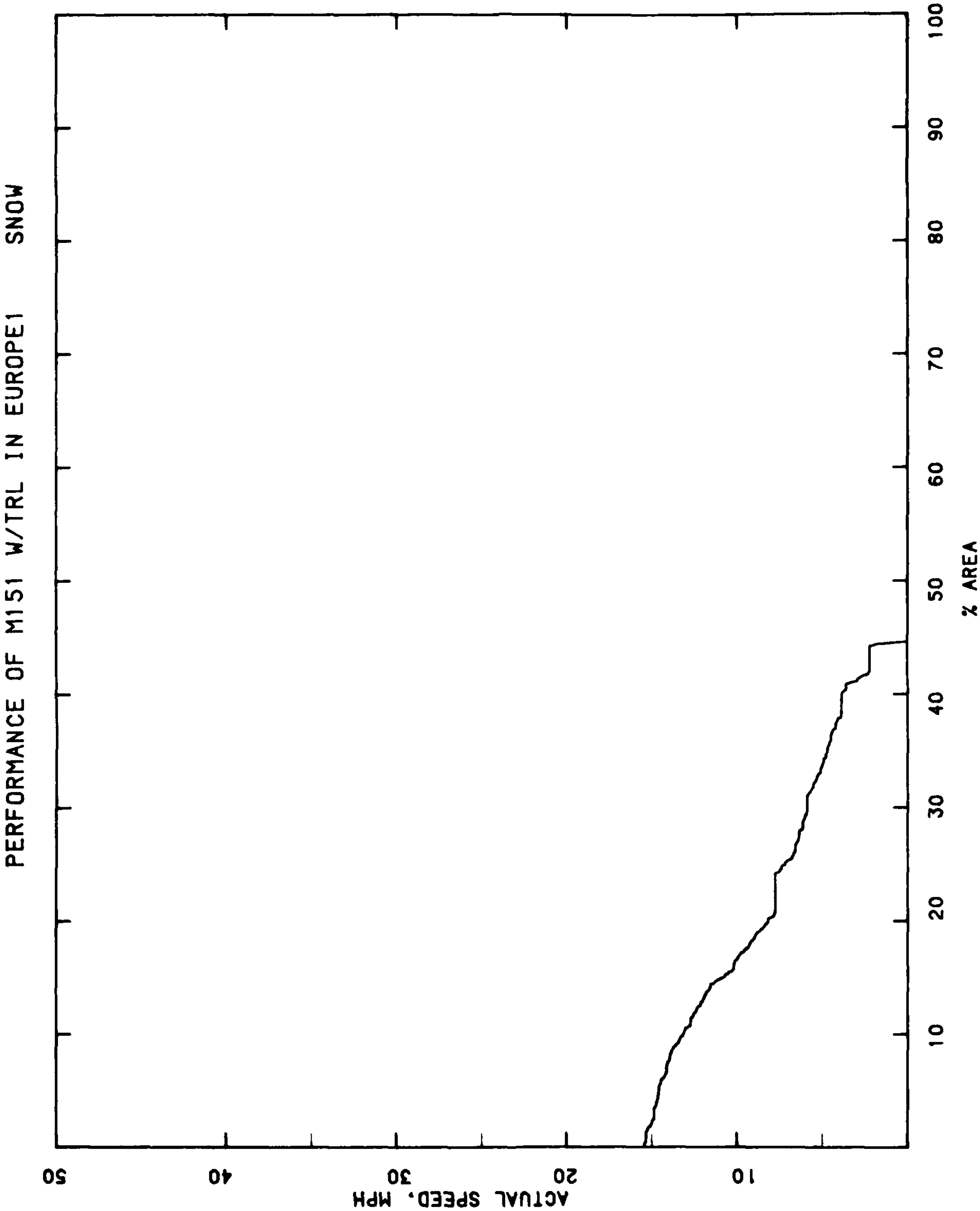


PERFORMANCE OF M151 W/TRL IN EUROPE1 WET



PERFORMANCE OF M151 W/TRL IN EUROPE1 SNOW




PERFORMANCE OF M151 W/TRL IN EUROPE1 SNOW
ACTUAL SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
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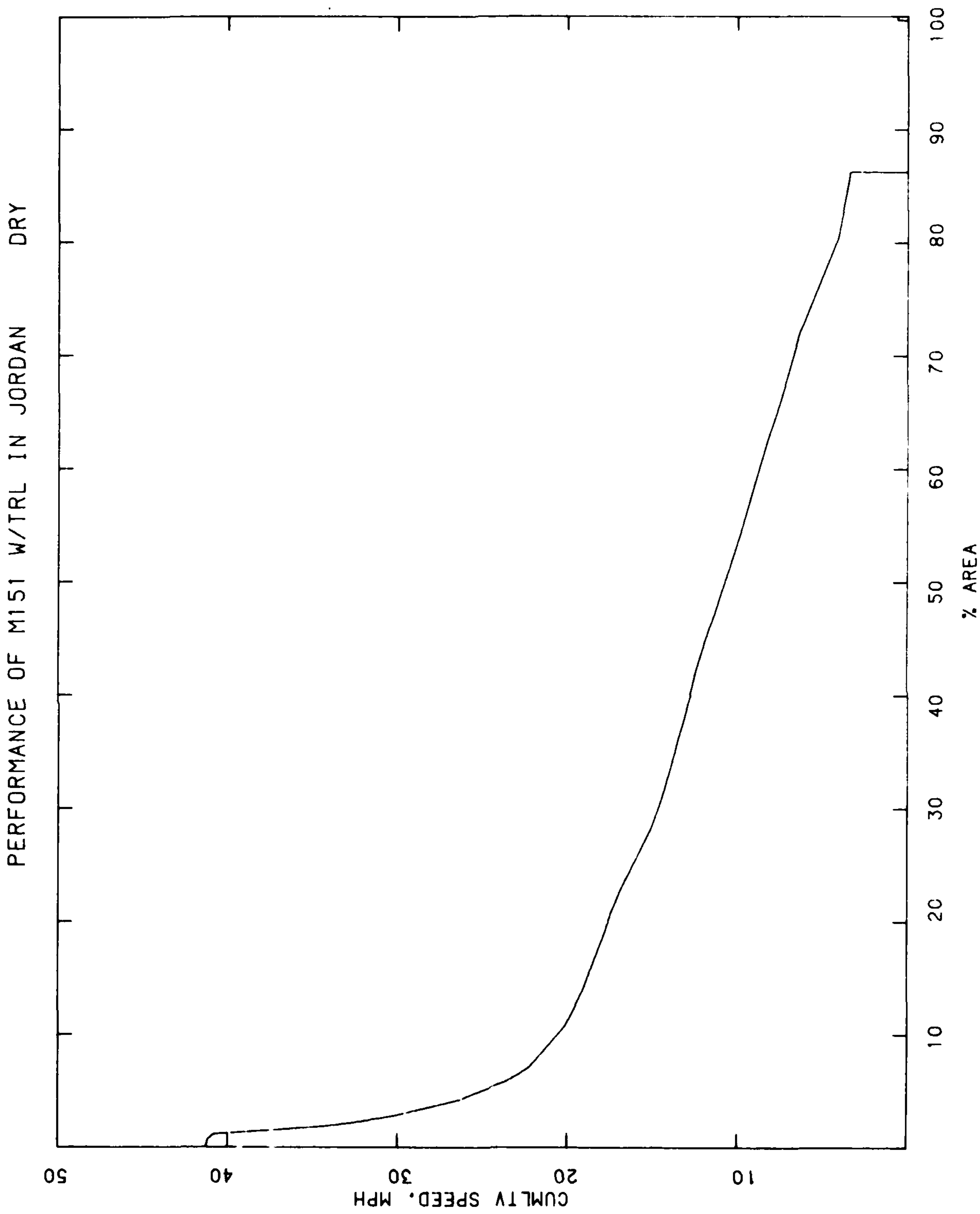
100
10
20
30
40
50


PERFORMANCE OF M151 W/TRL IN JORDAN DRY
CUMLTV SPEED, MPH
% AREA
10
20
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40
50
60
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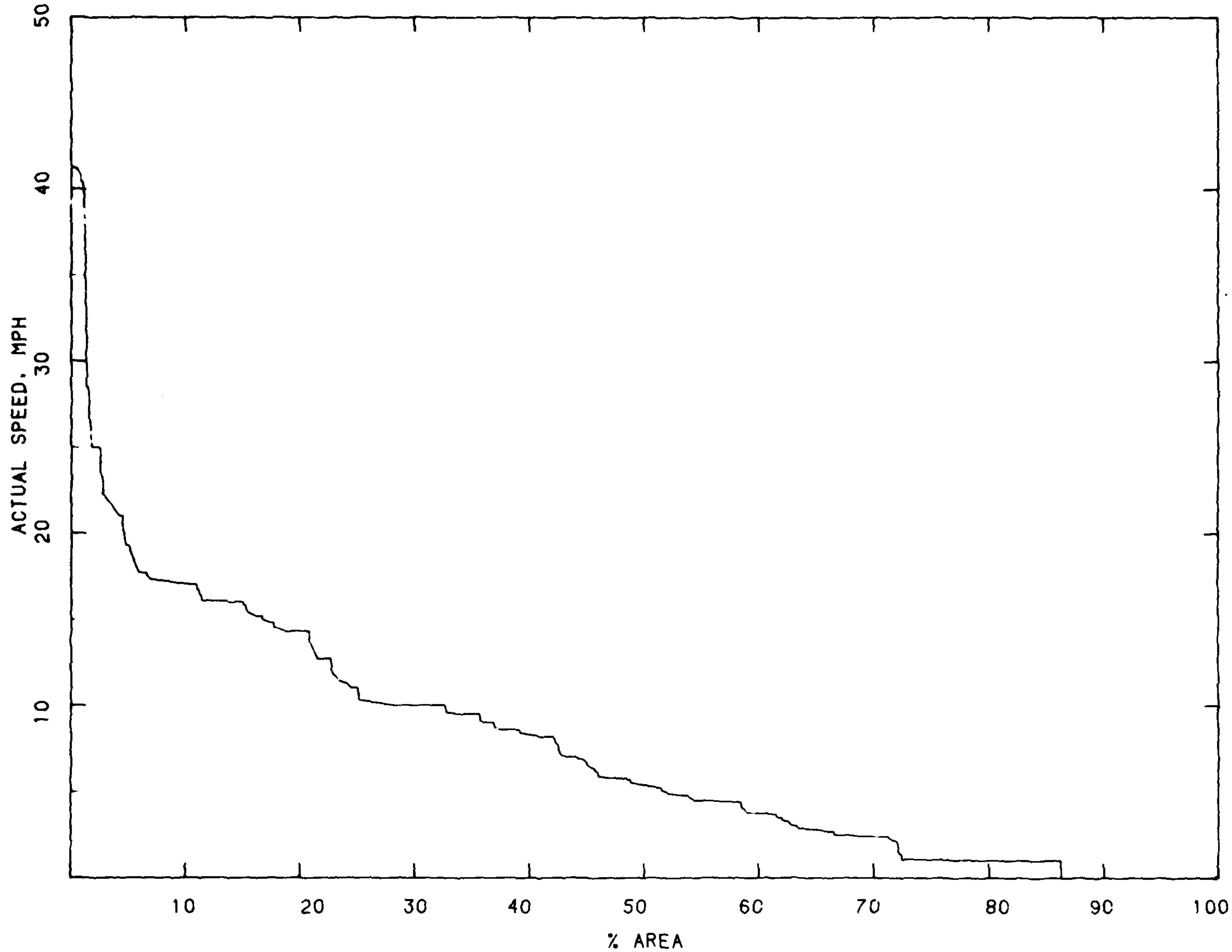
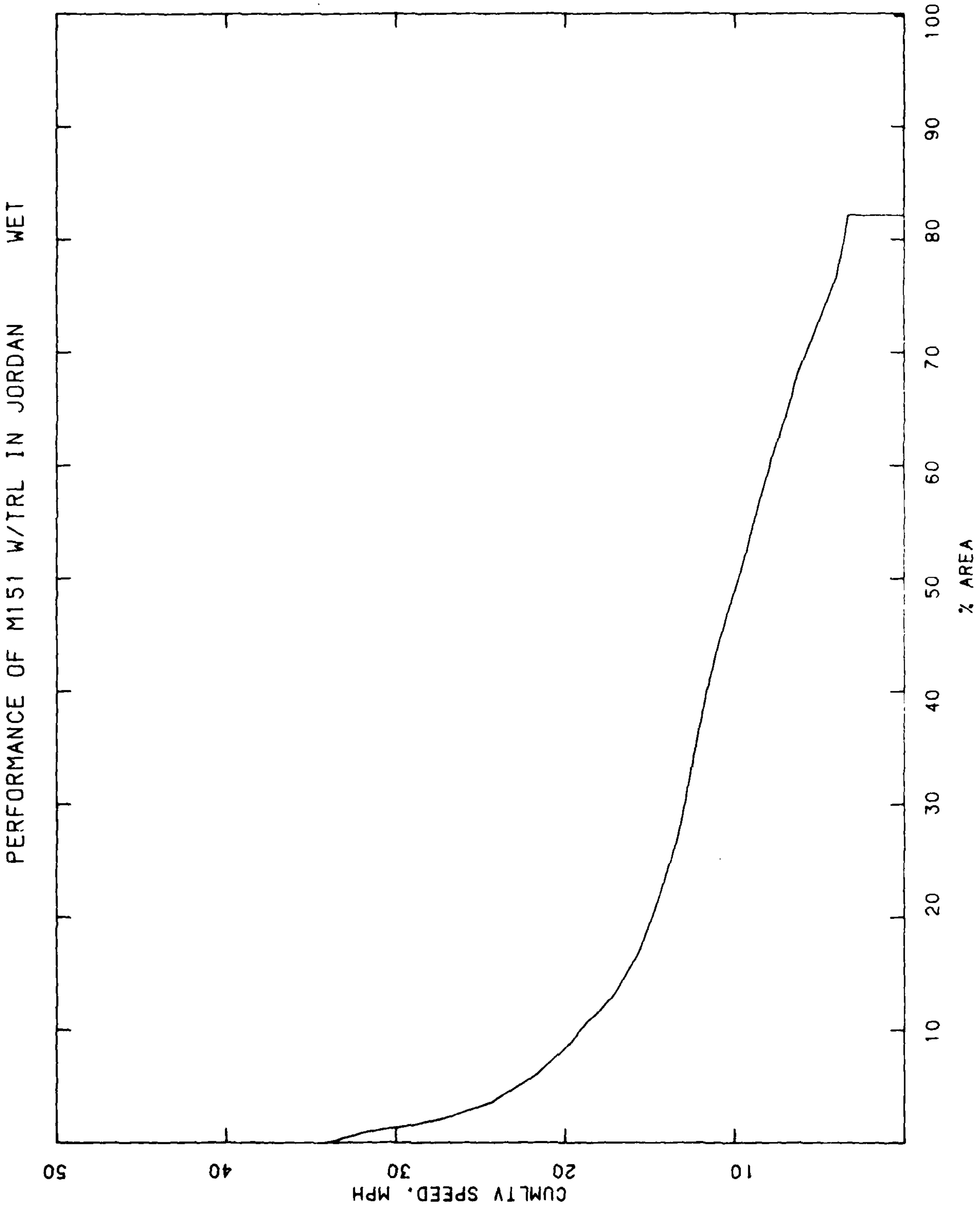
80
90
100
10
20
30
40
50

PERFORMANCE OF M151 W/TRL IN JORDAN DRY





PERFORMANCE OF M151 W/TRL IN JORDAN WET
CUMLTV SPEED, MPH
% AREA
10
20
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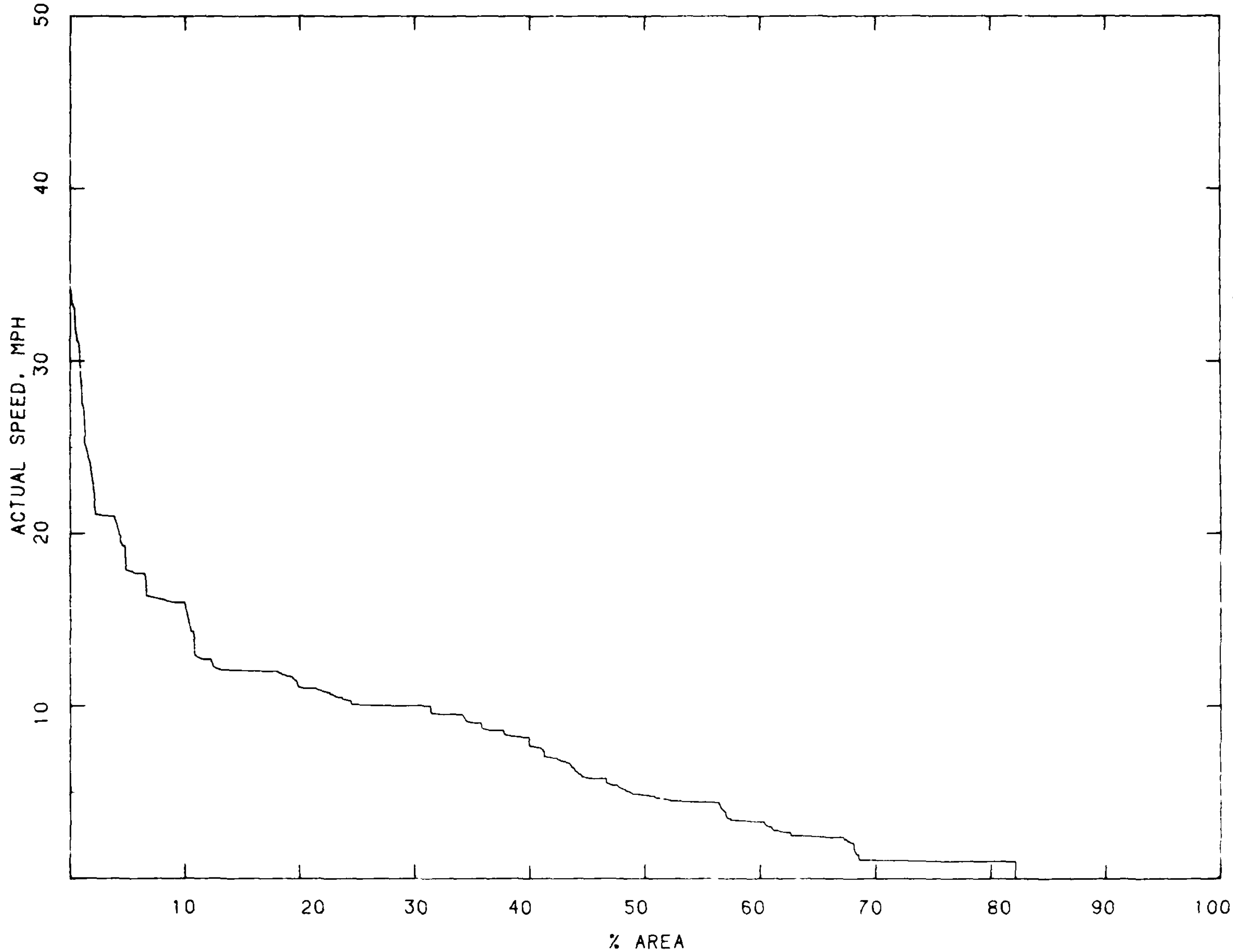
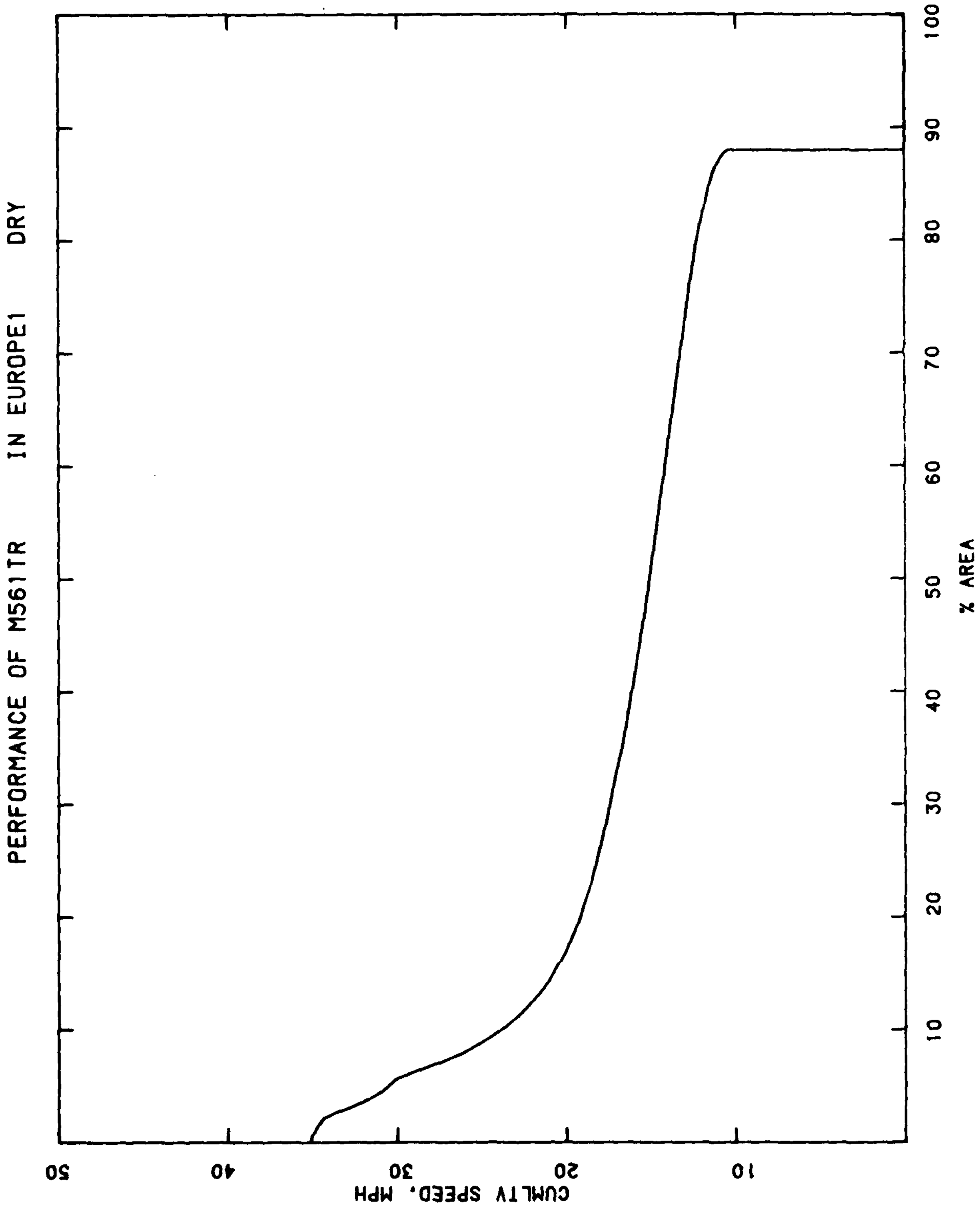
40
50
60
70
80
90
100

PERFORMANCE OF M151 W/TRL IN JORDAN WET




PERFORMANCE OF M561TR IN EUROPE1 DRY
CUMLTV SPEED, MPH
50
40
30
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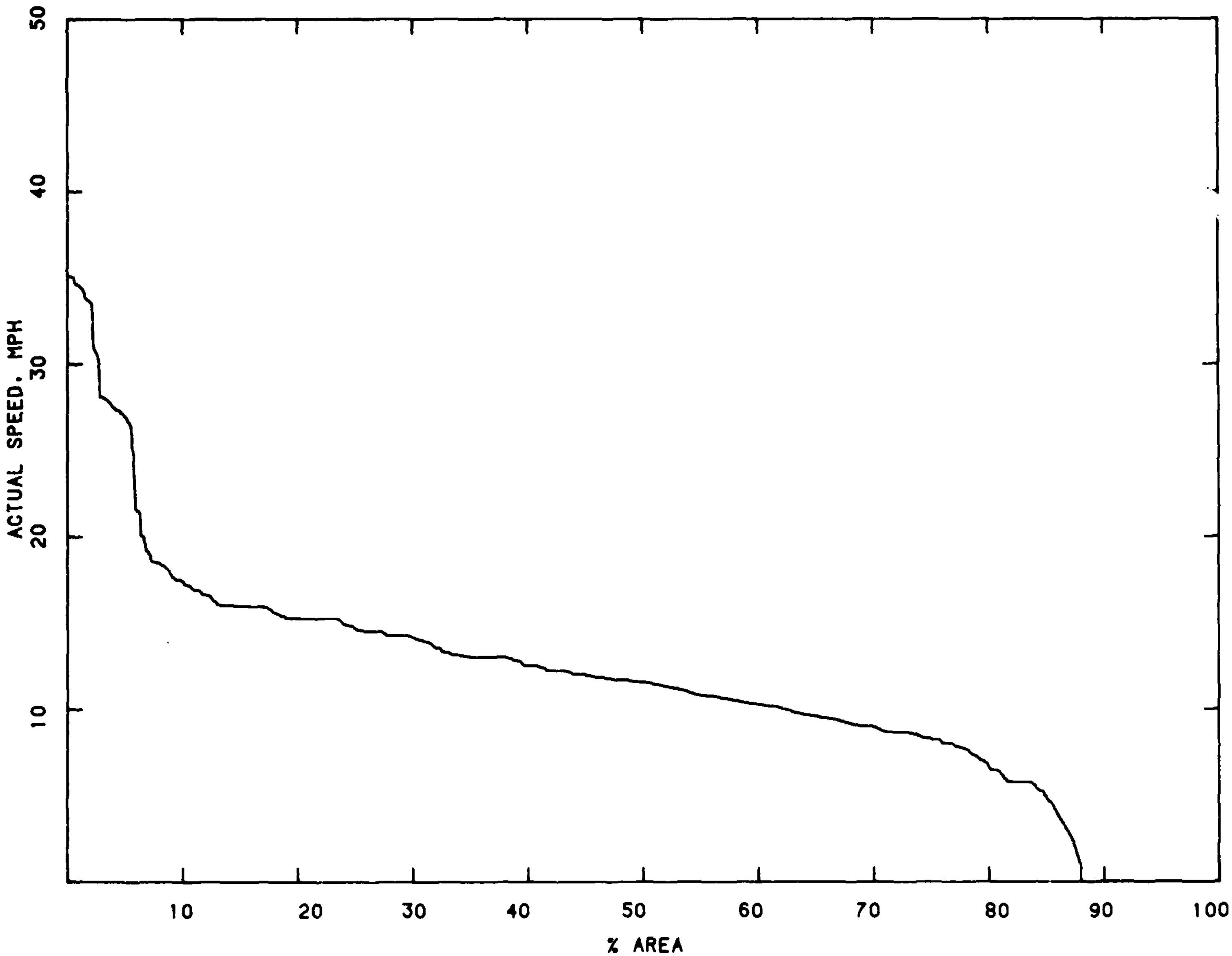
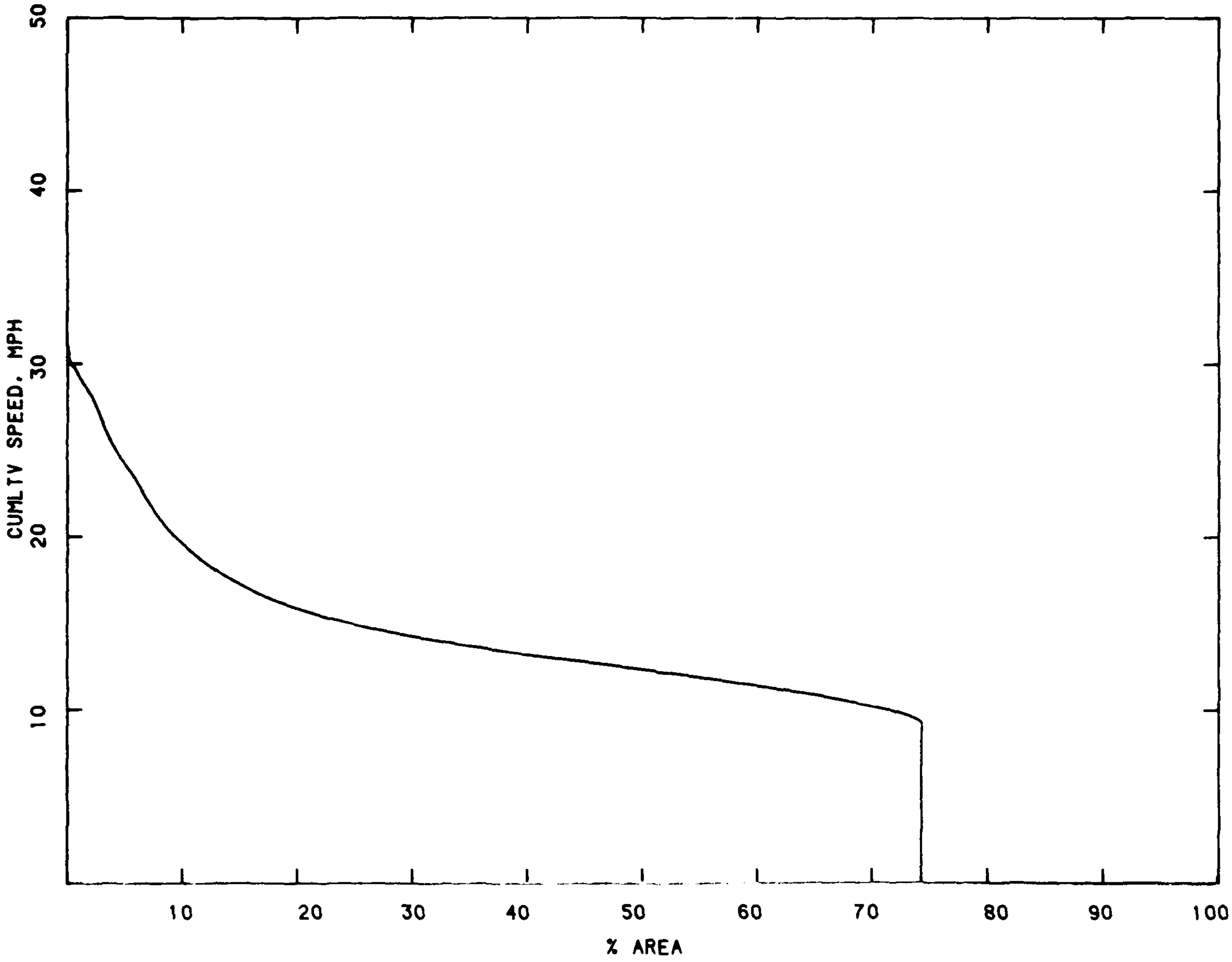
10
% AREA
10
20
30
40
50
60
70
80
90
100

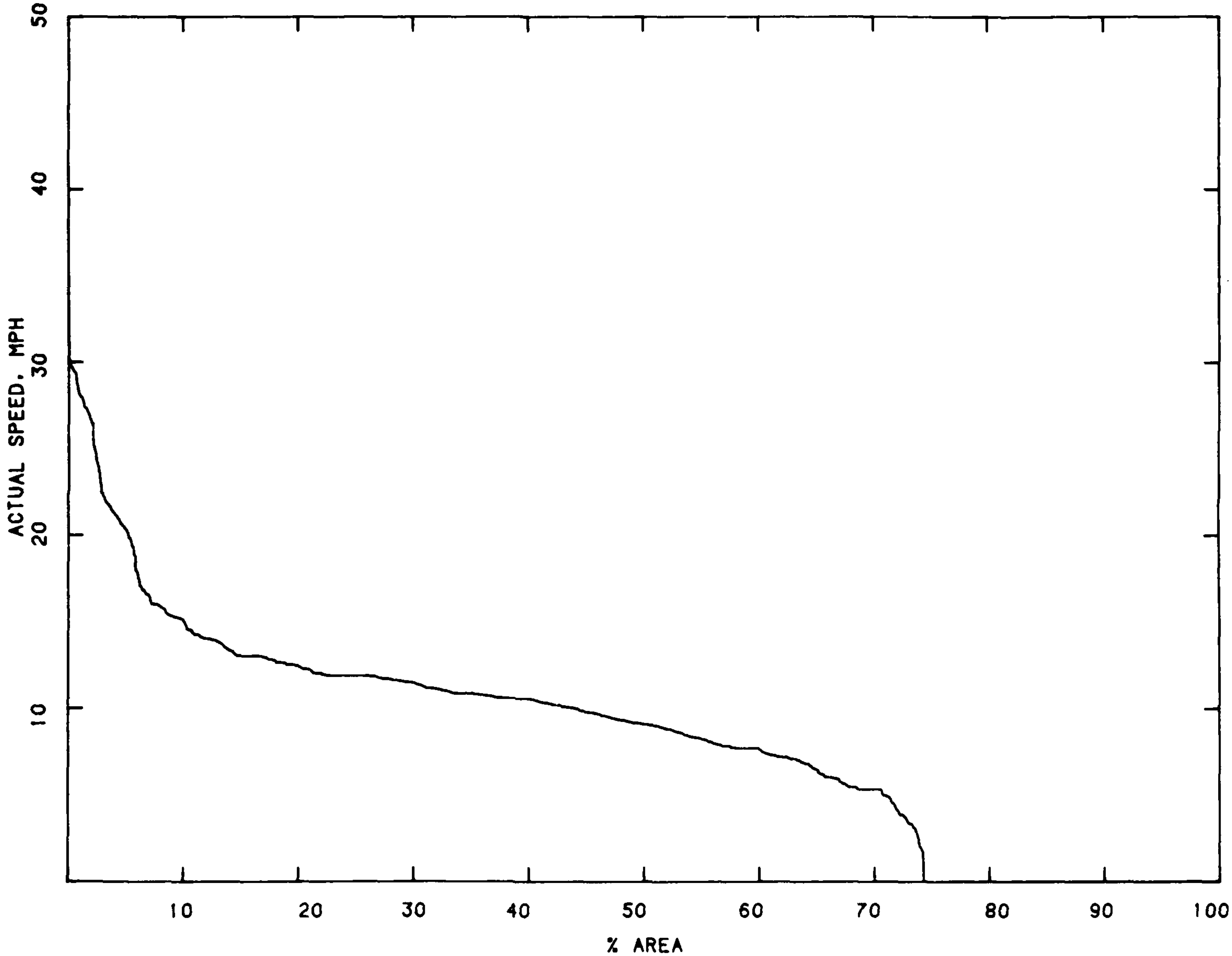
PERFORMANCE OF M561TR IN EUROPE1 DRY



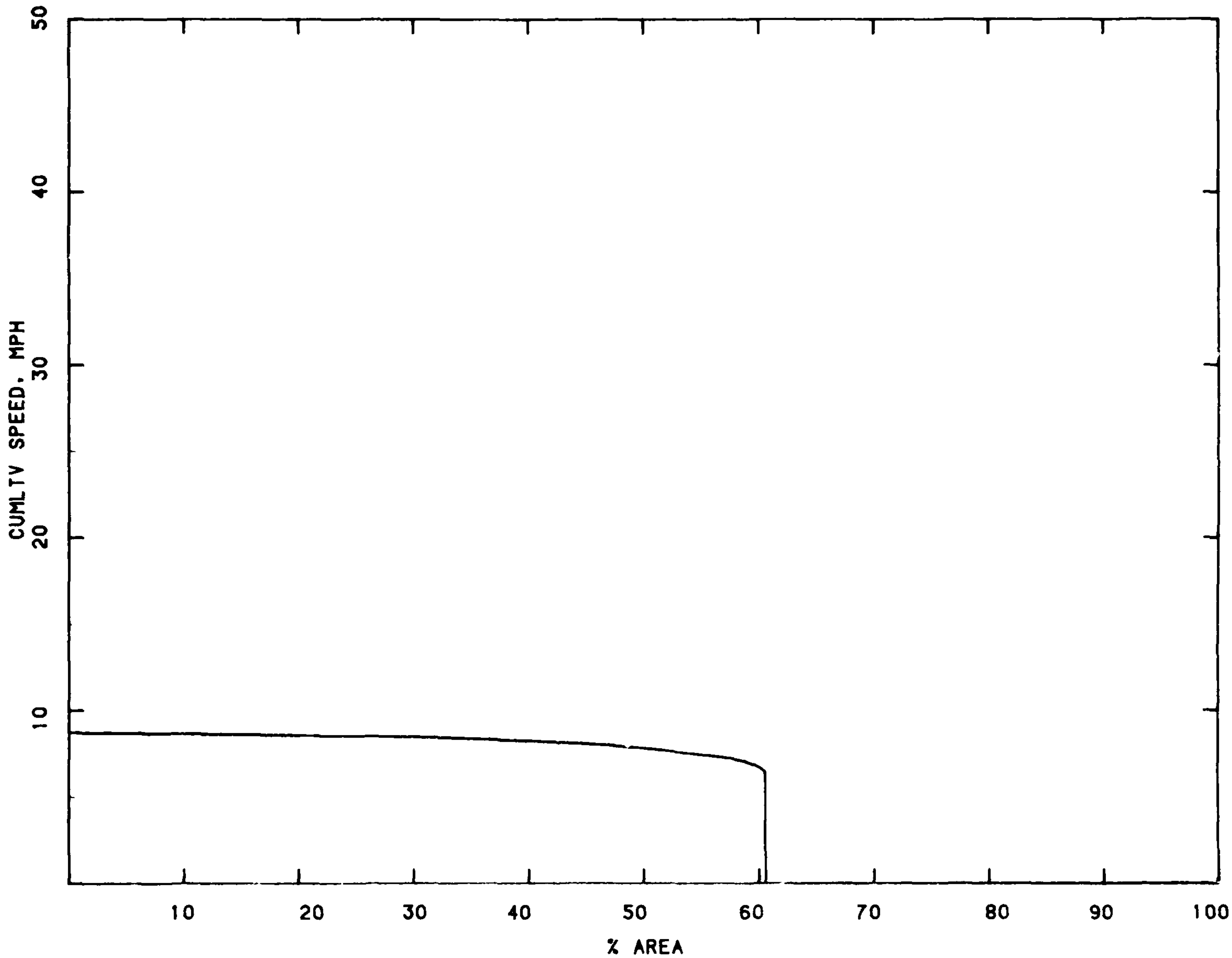
PERFORMANCE OF M561TR IN EUROPE1 WET



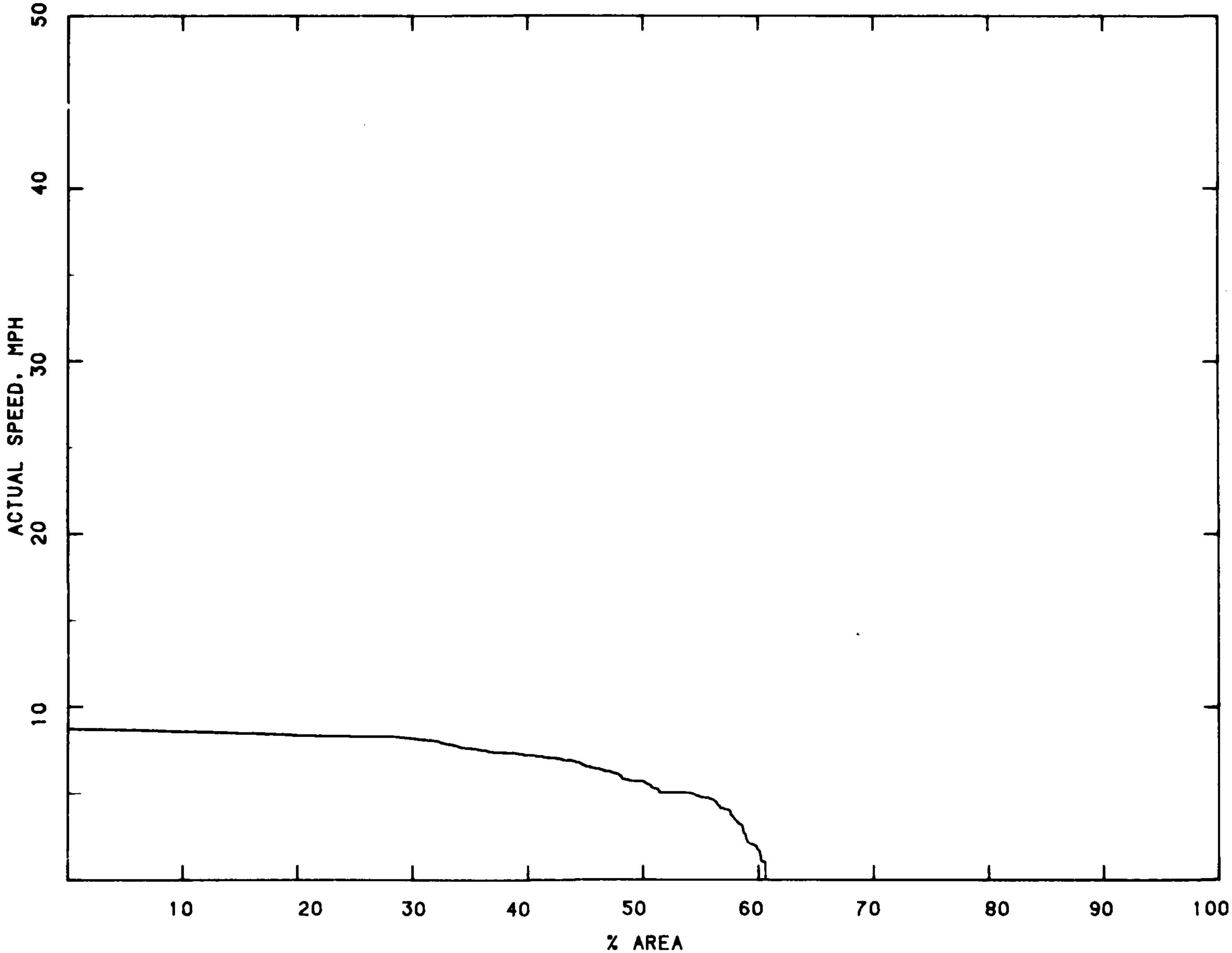
PERFORMANCE OF M561TR IN EUROPE1 WET

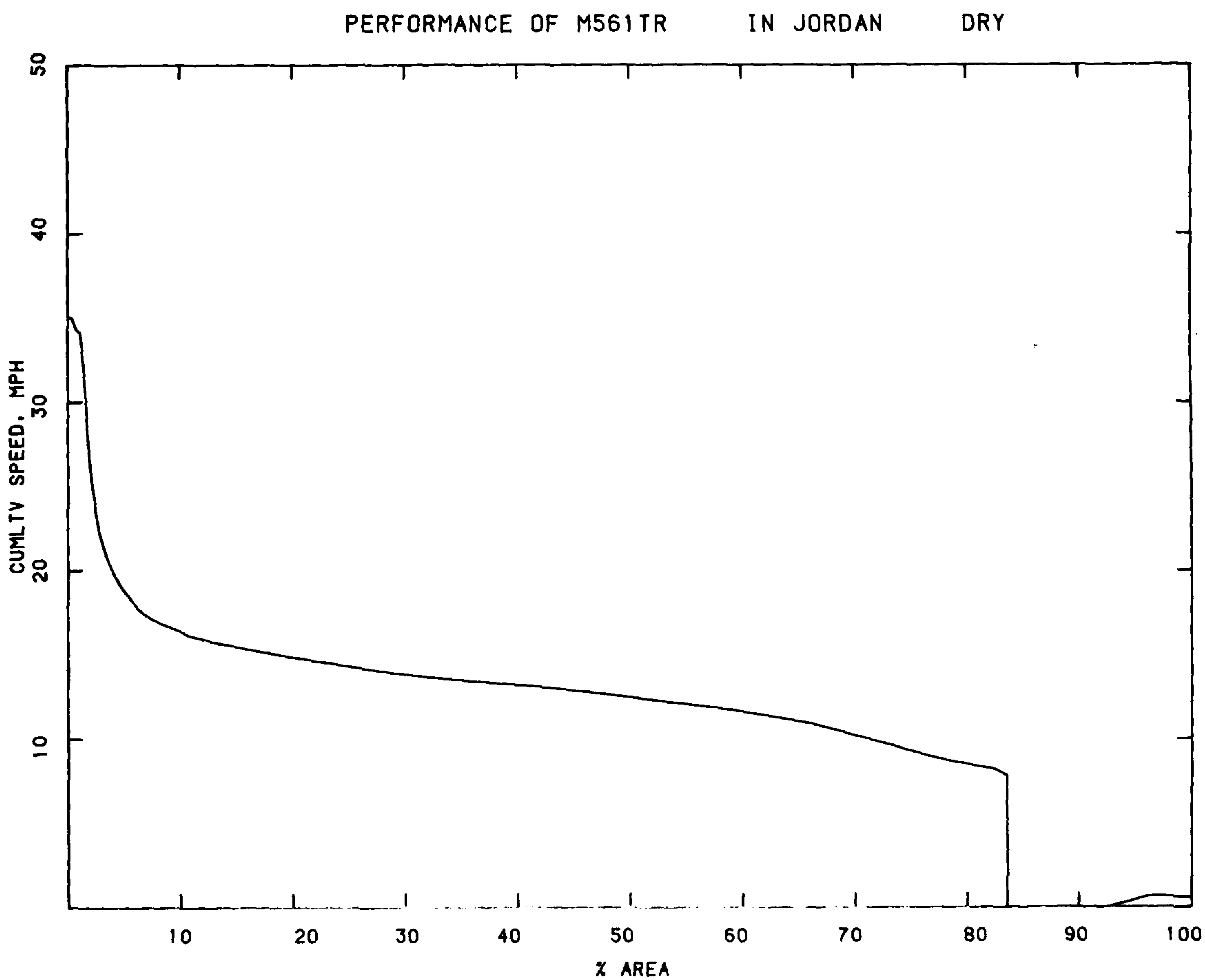


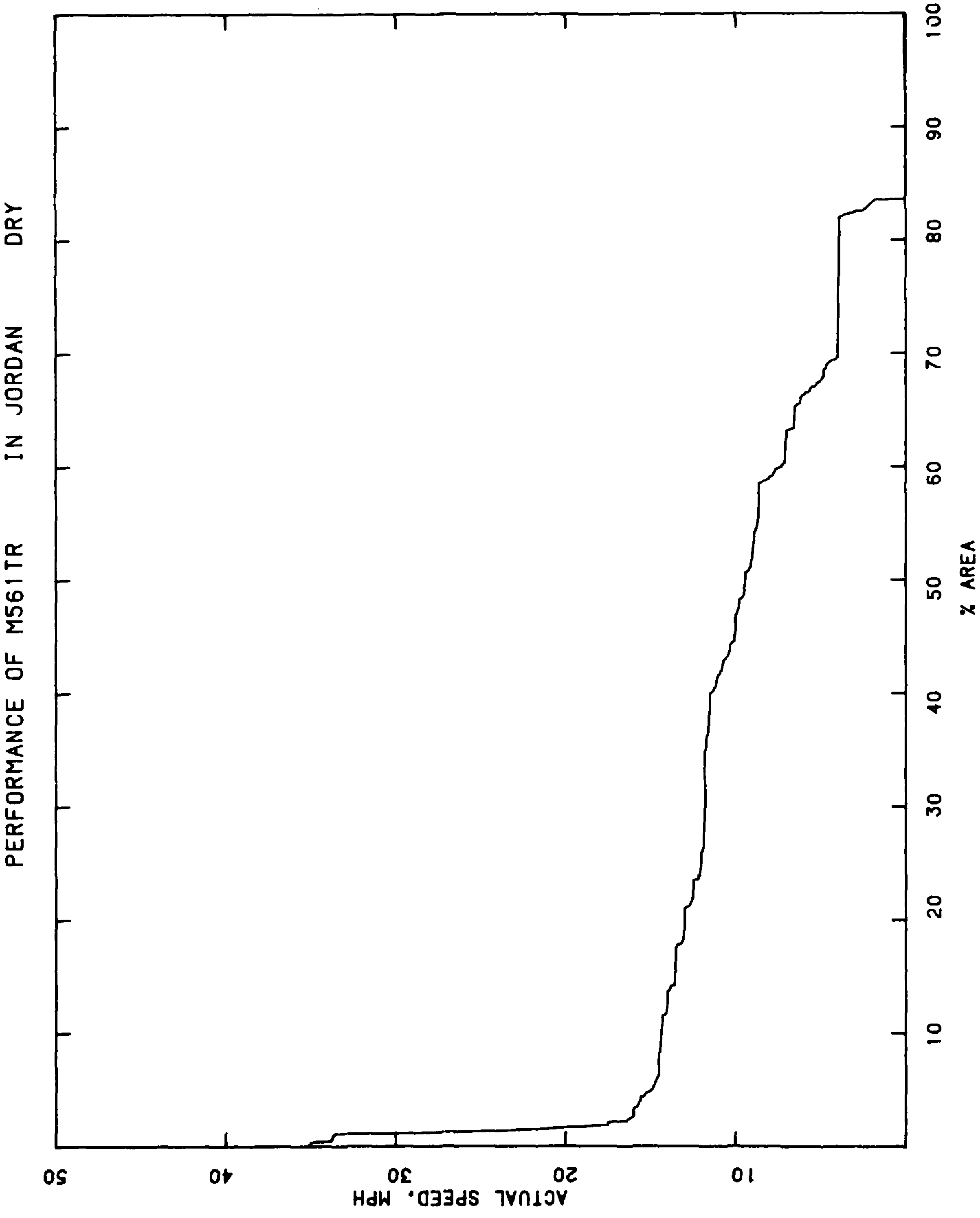
PERFORMANCE OF M561TR IN EUROPE1 SNOW

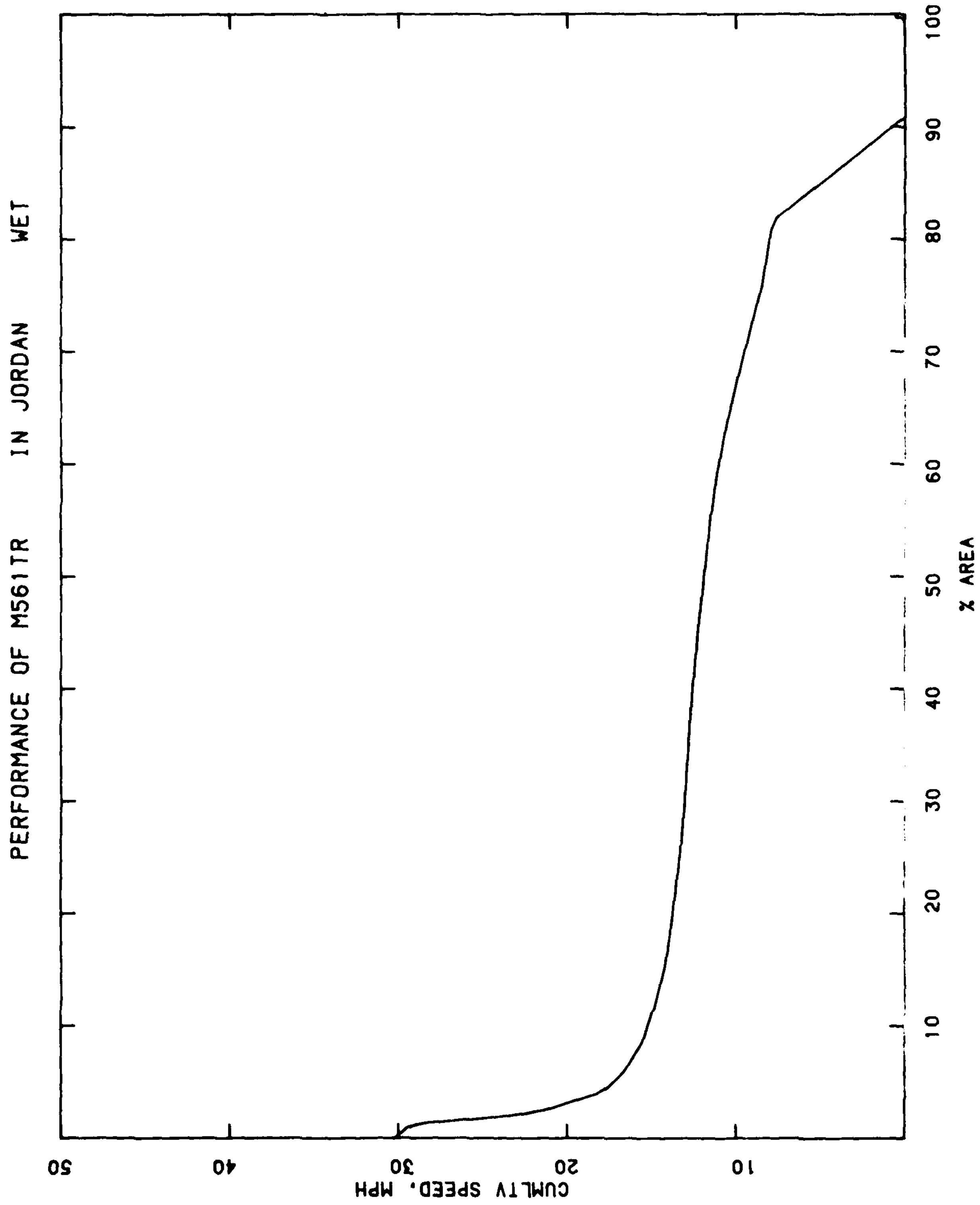


PERFORMANCE OF M561TR IN EUROPE1 SNOW




PERFORMANCE OF M561TR IN JORDAN DRY
CUMLTV SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF M561TR IN JORDAN DRY
ACTUAL SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF M561TR IN JORDAN WET
CUMLTV SPEED, MPH
% AREA
50
40
30
20
10
10
20
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40
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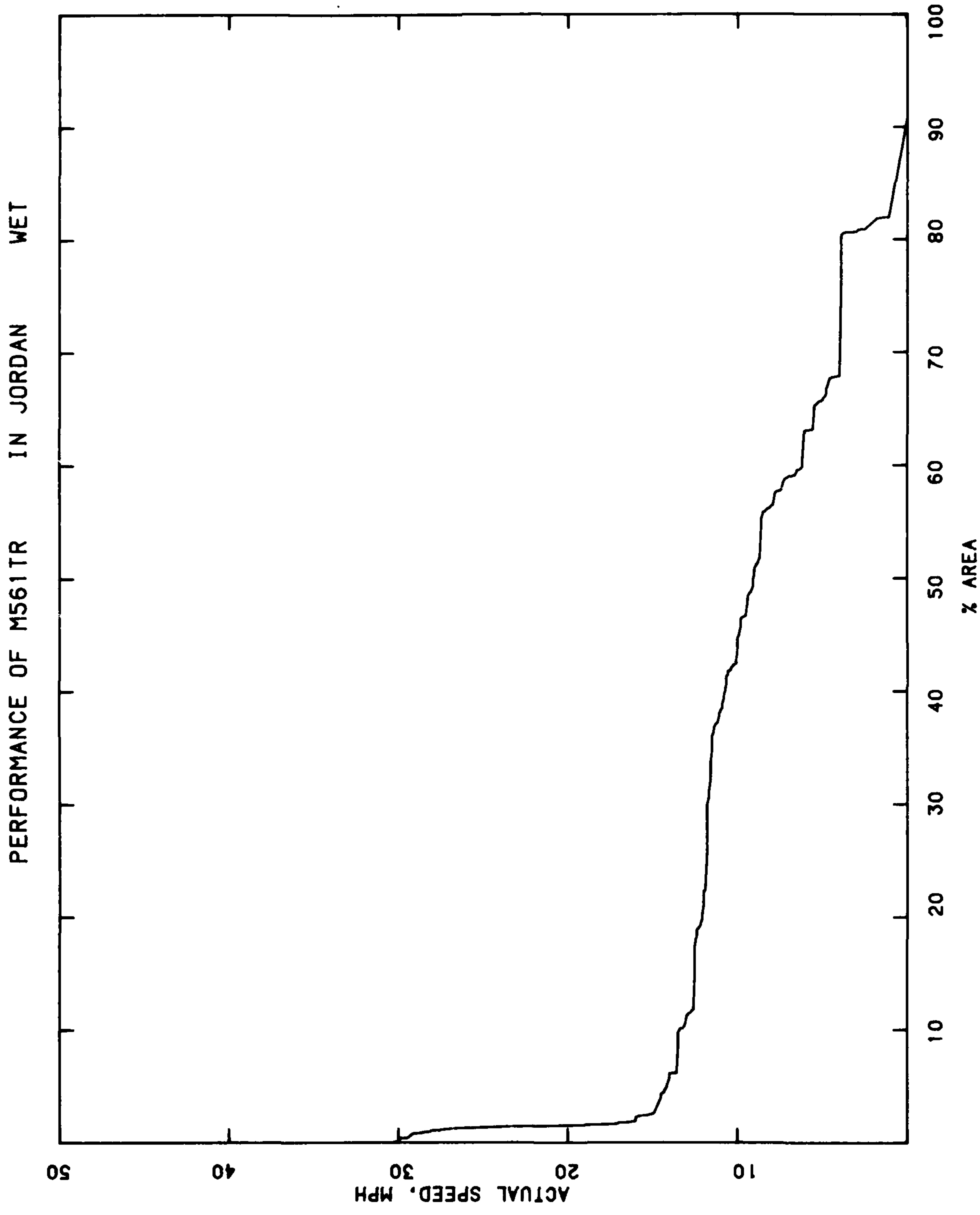
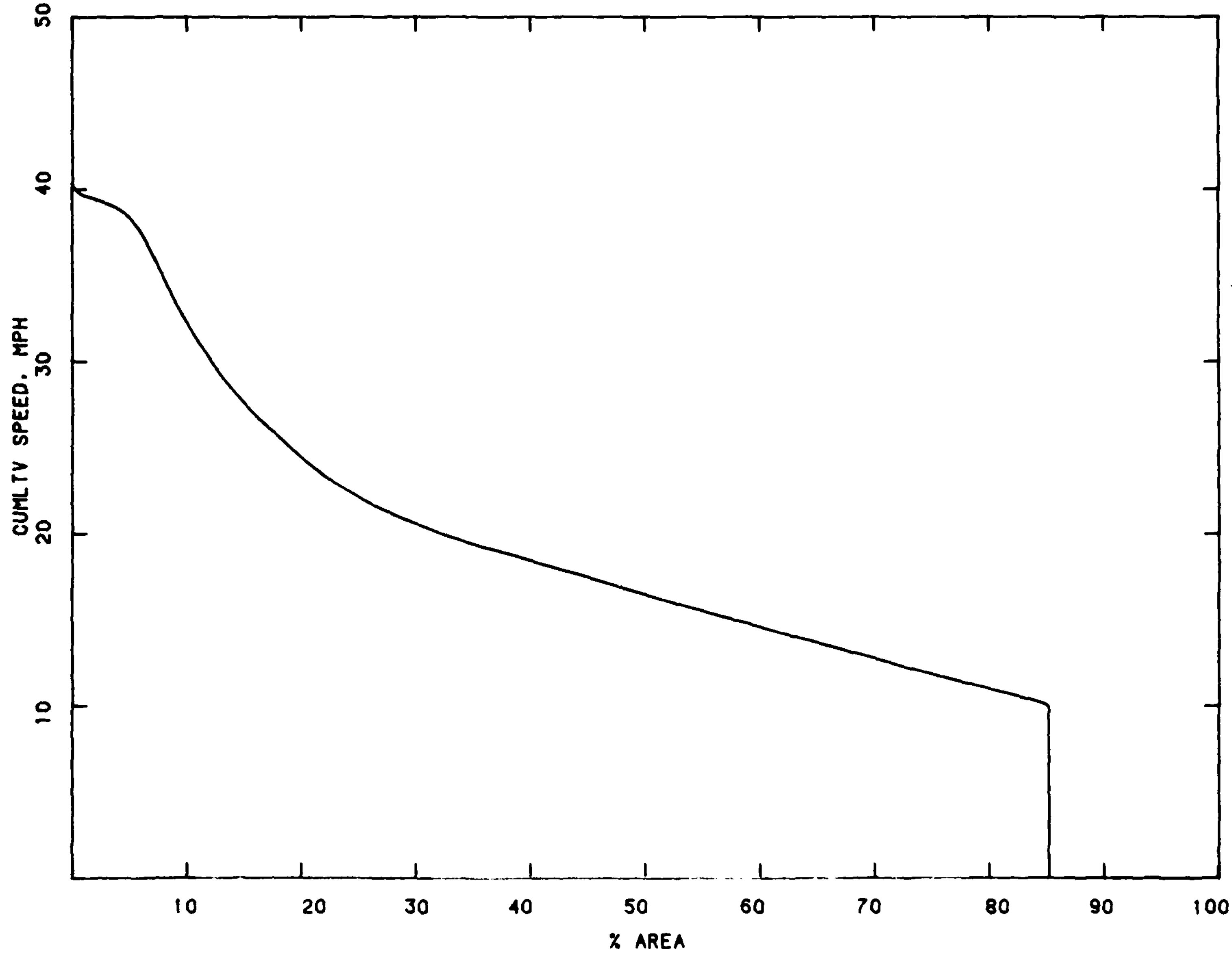
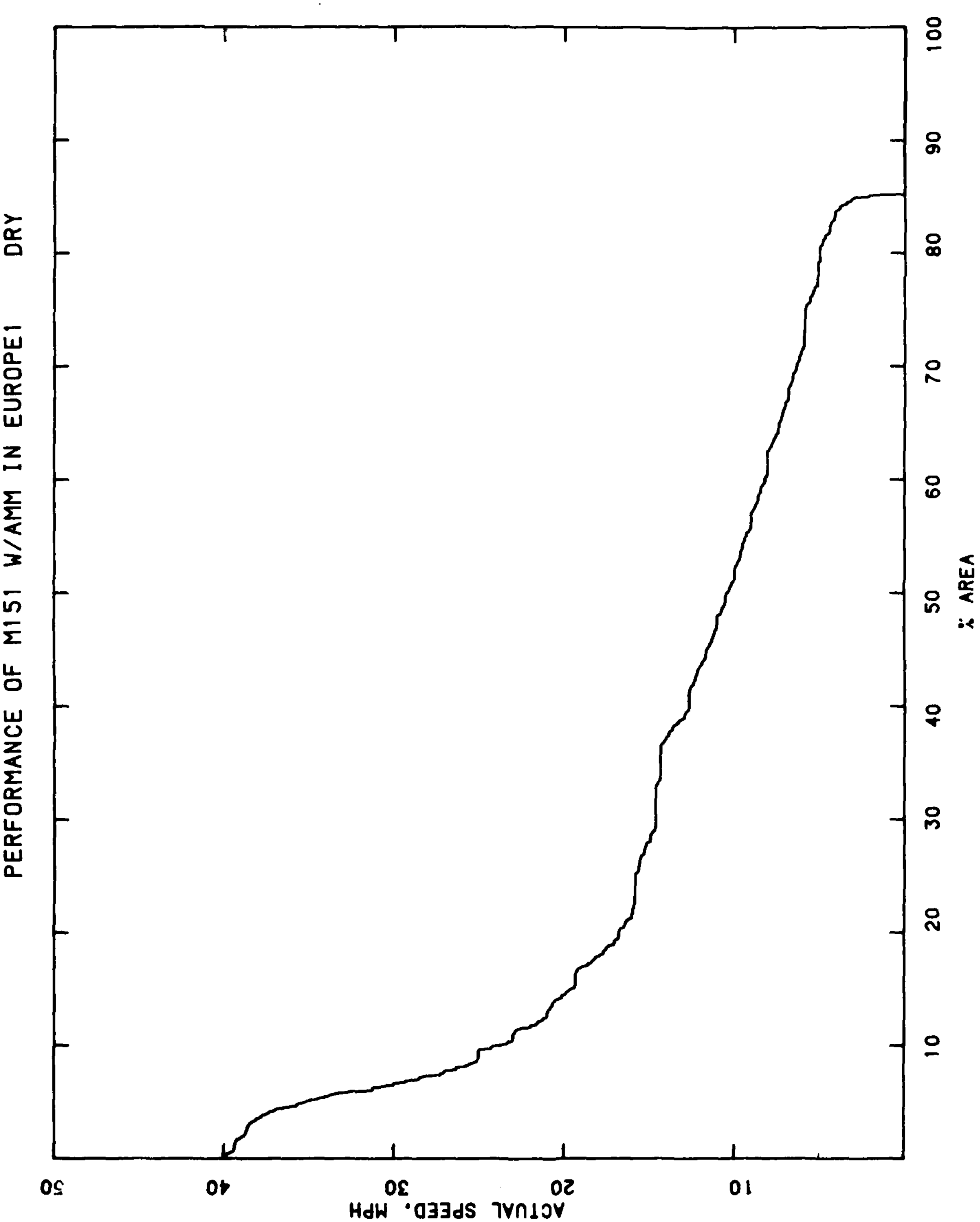
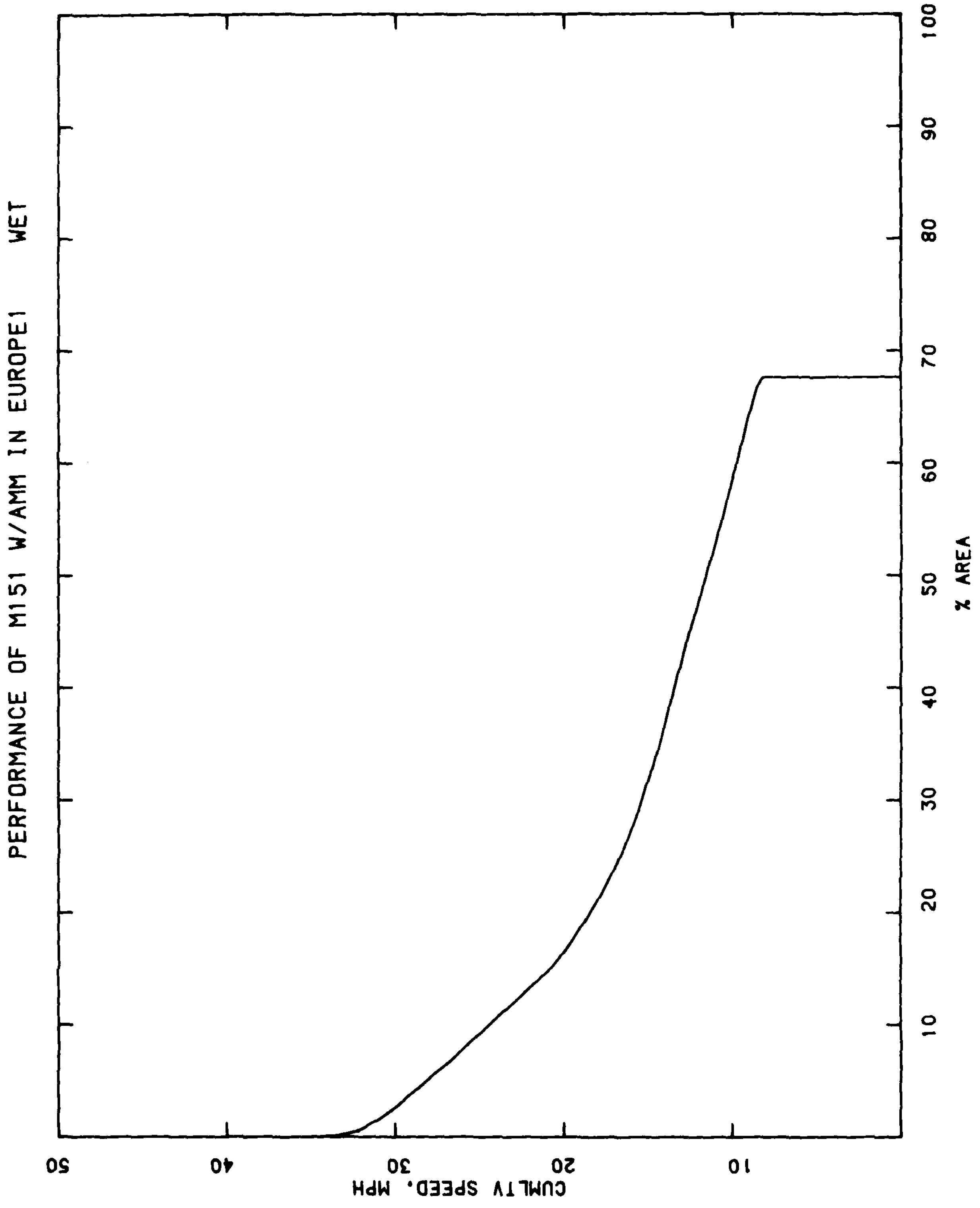
60
70
80
90
100


PERFORMANCE OF M561TR IN JORDAN WET
ACTUAL SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100

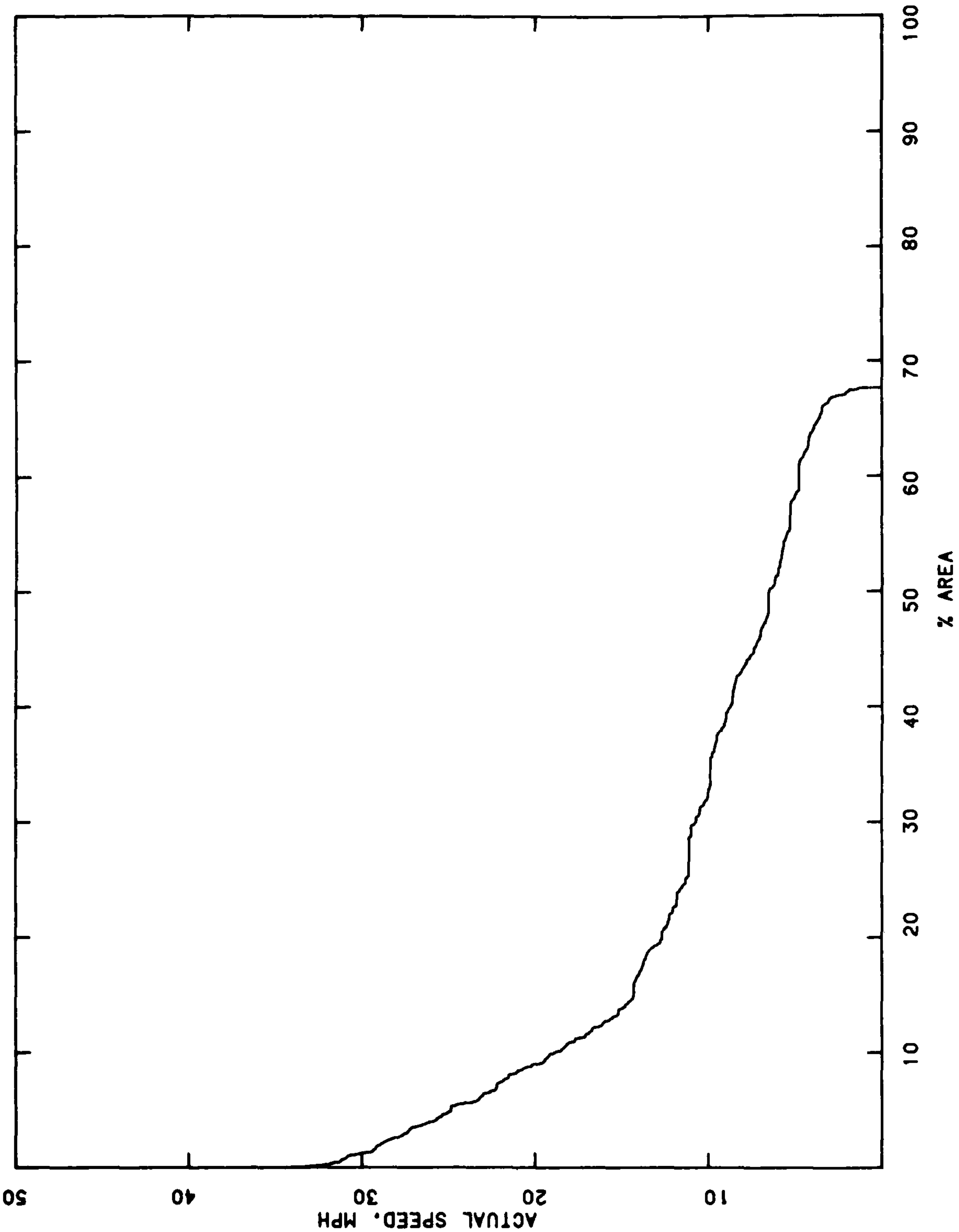
PERFORMANCE OF M151 W/AMM IN EUROPE1 DRY

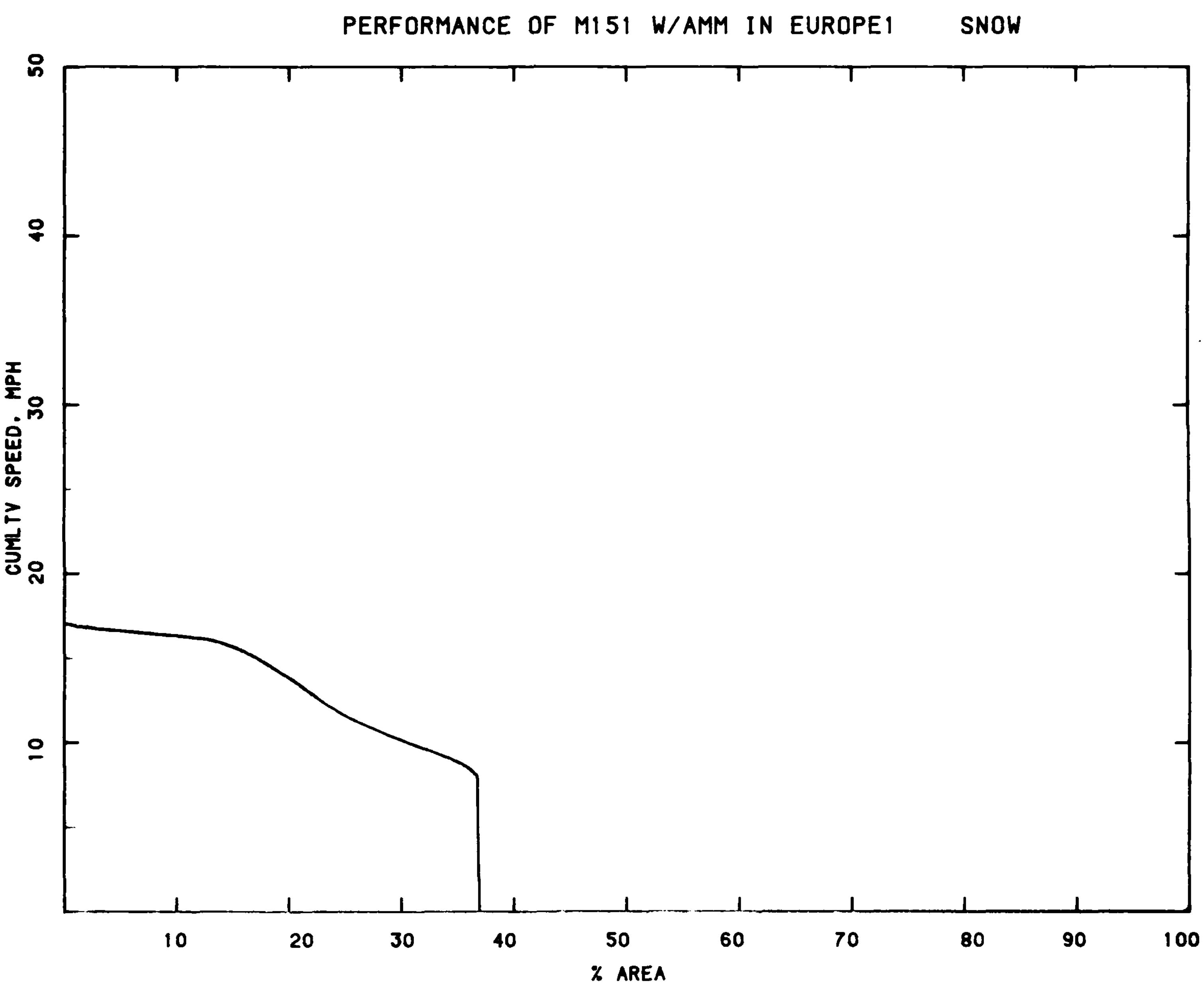



PERFORMANCE OF M151 W/AMM IN EUROPE1 DRY
% AREA
ACTUAL SPEED, MPH
0 10 20 30 40 50 60 70 80 90 100
10 20 30 40 50

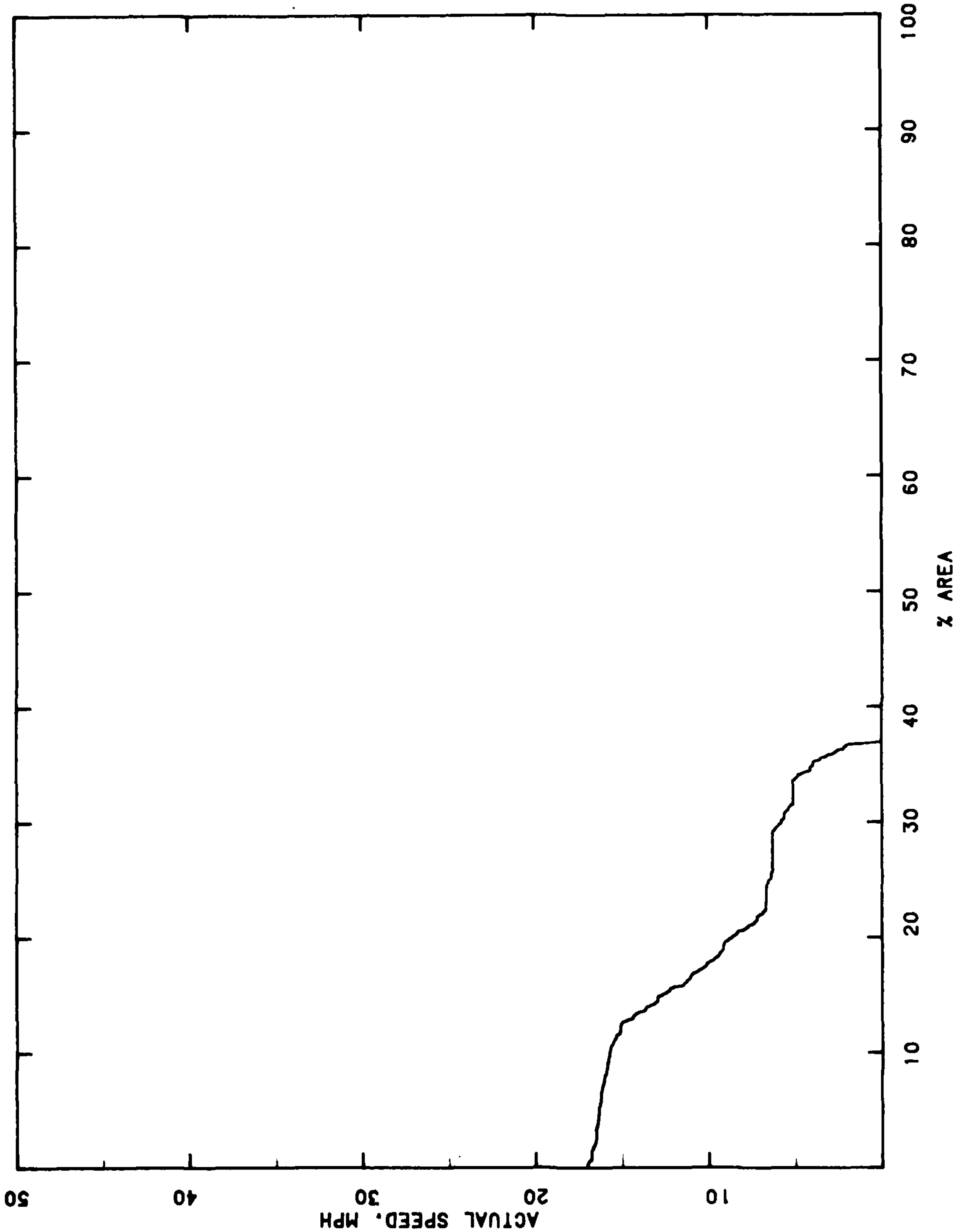

PERFORMANCE OF M151 W/AMM IN EUROPE1 WET
CUMLTV SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100
10
20
30
40
50

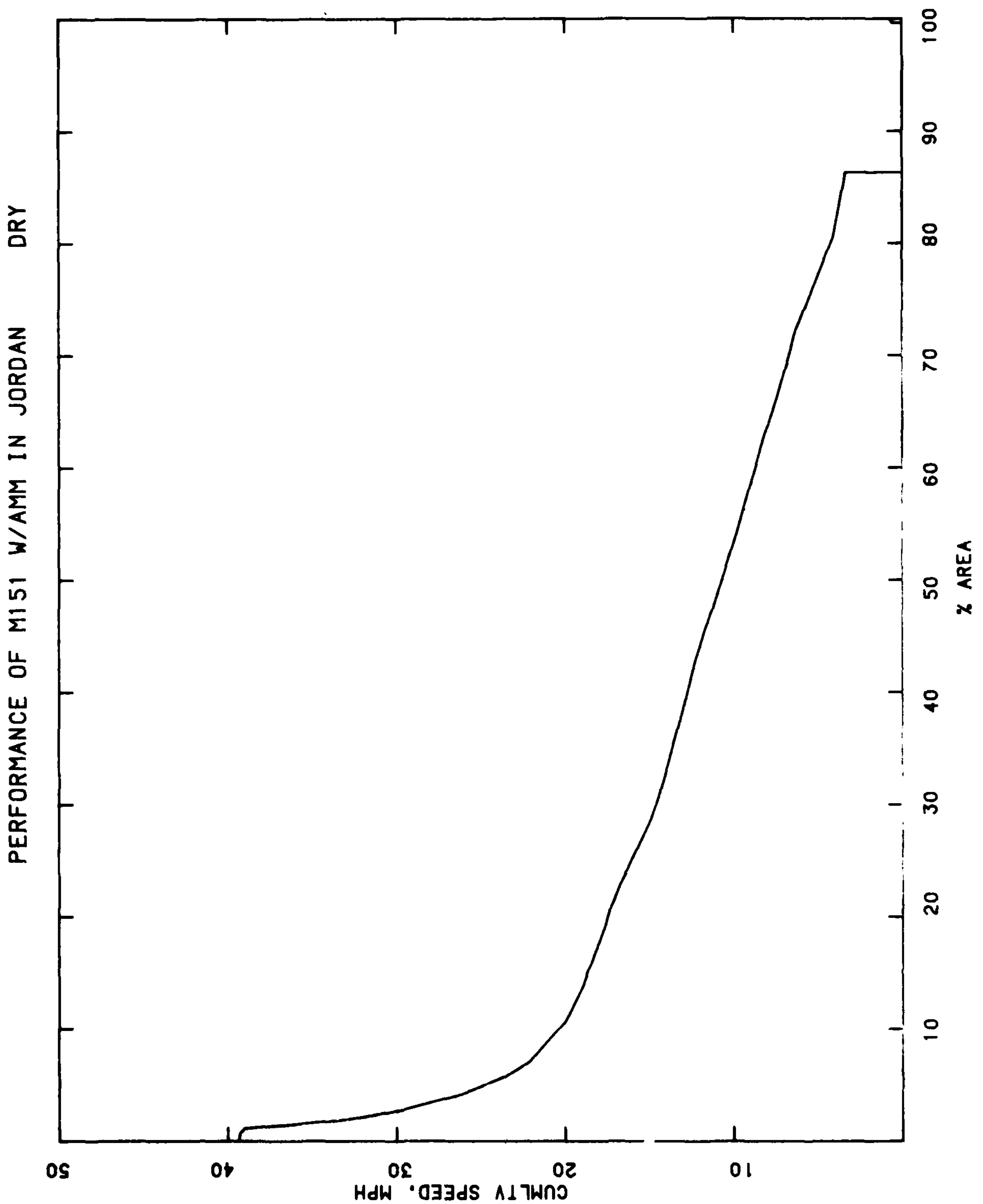
PERFORMANCE OF M151 W/AMM IN EUROPE1   WET



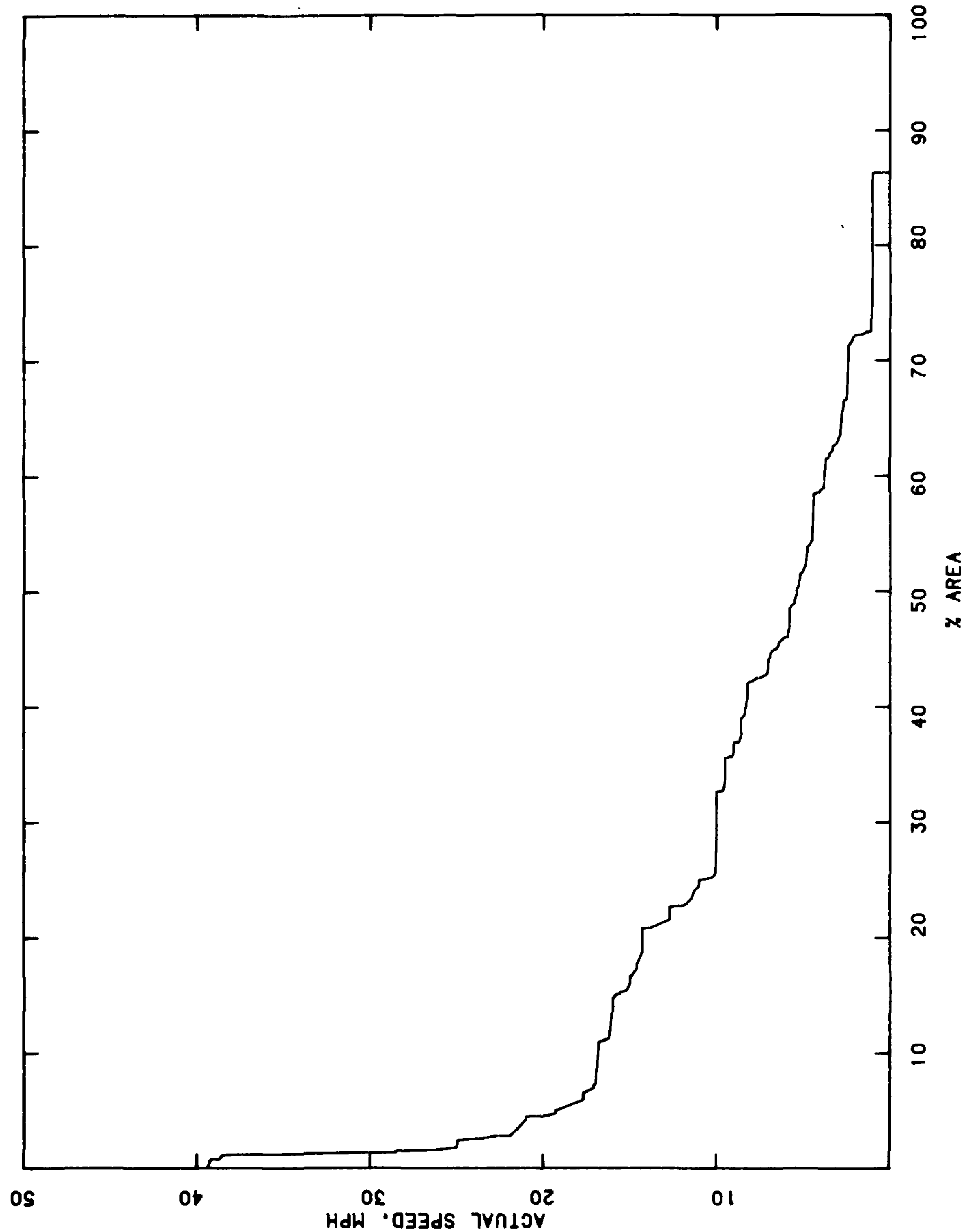

PERFORMANCE OF M151 W/AMM IN EUROPE1 SNOW
CUMLTV SPEED, MPH
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
% AREA

PERFORMANCE OF M151 W/AMM IN EUROPE1 SNOW

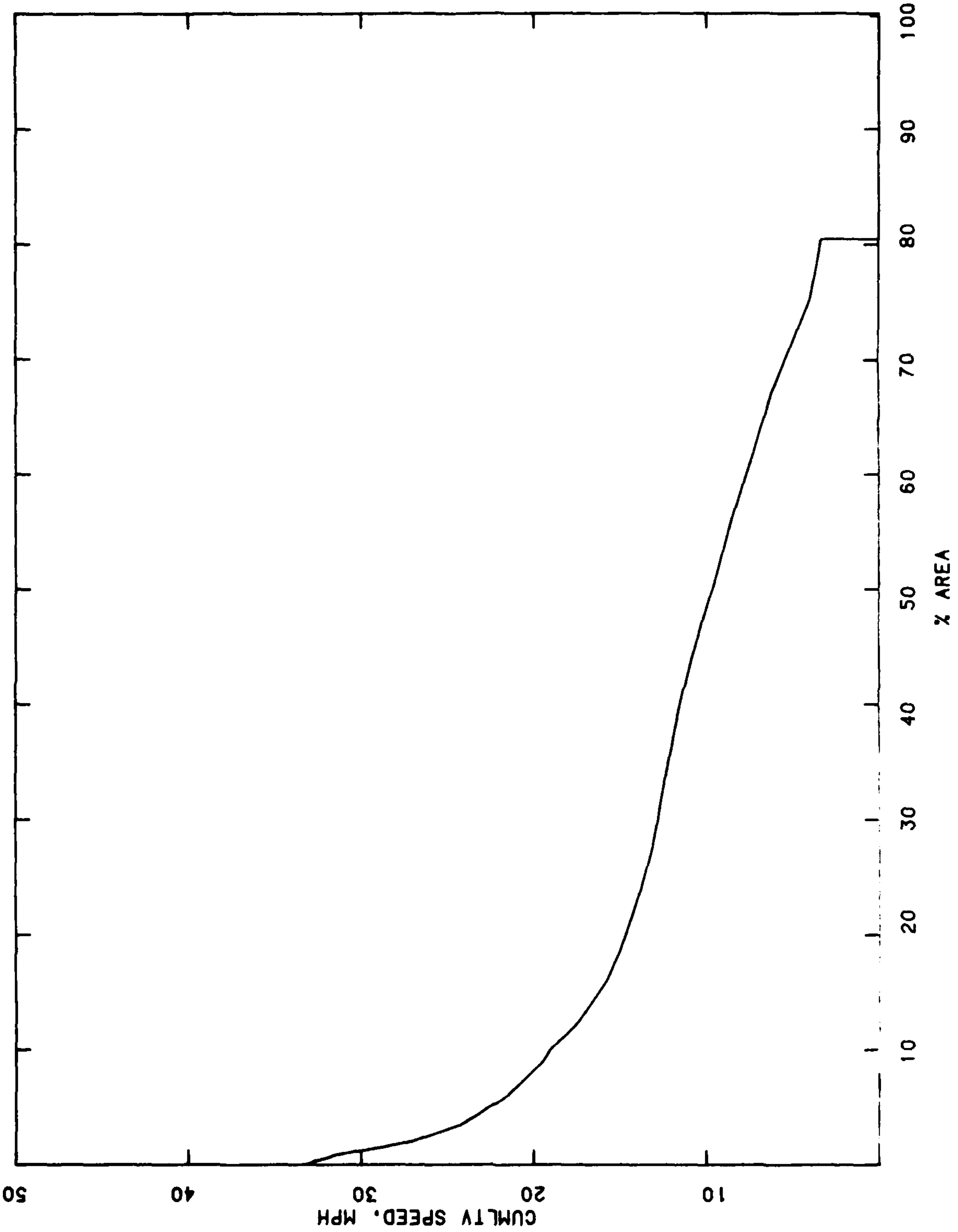



PERFORMANCE OF M151 W/AMM IN JORDAN DRY
CUMLTV SPEED, MPH
% AREA
0
10
20
30
40
50
60
70
80
90
100

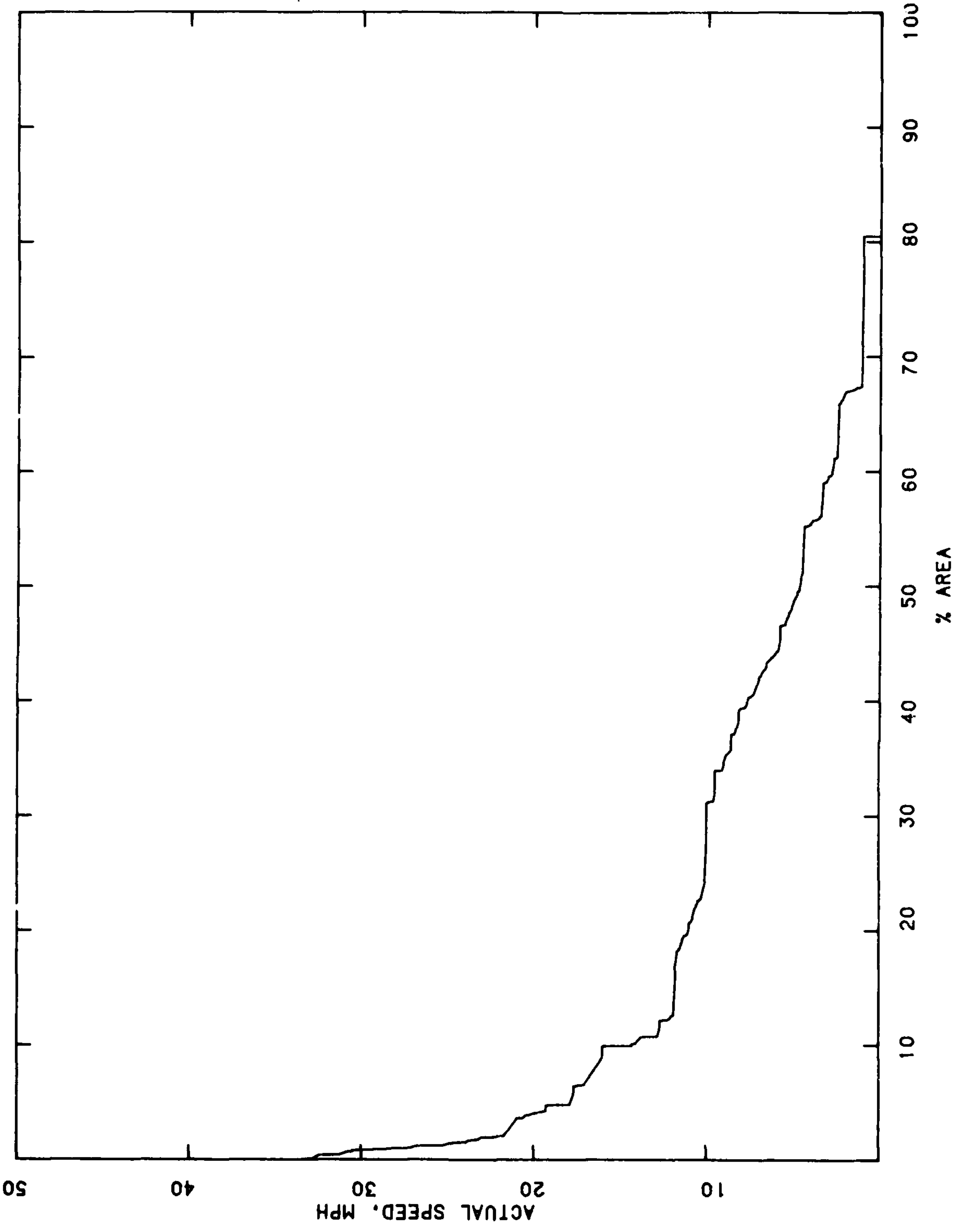
PERFORMANCE OF M151 W/AMM IN JORDAN DRY



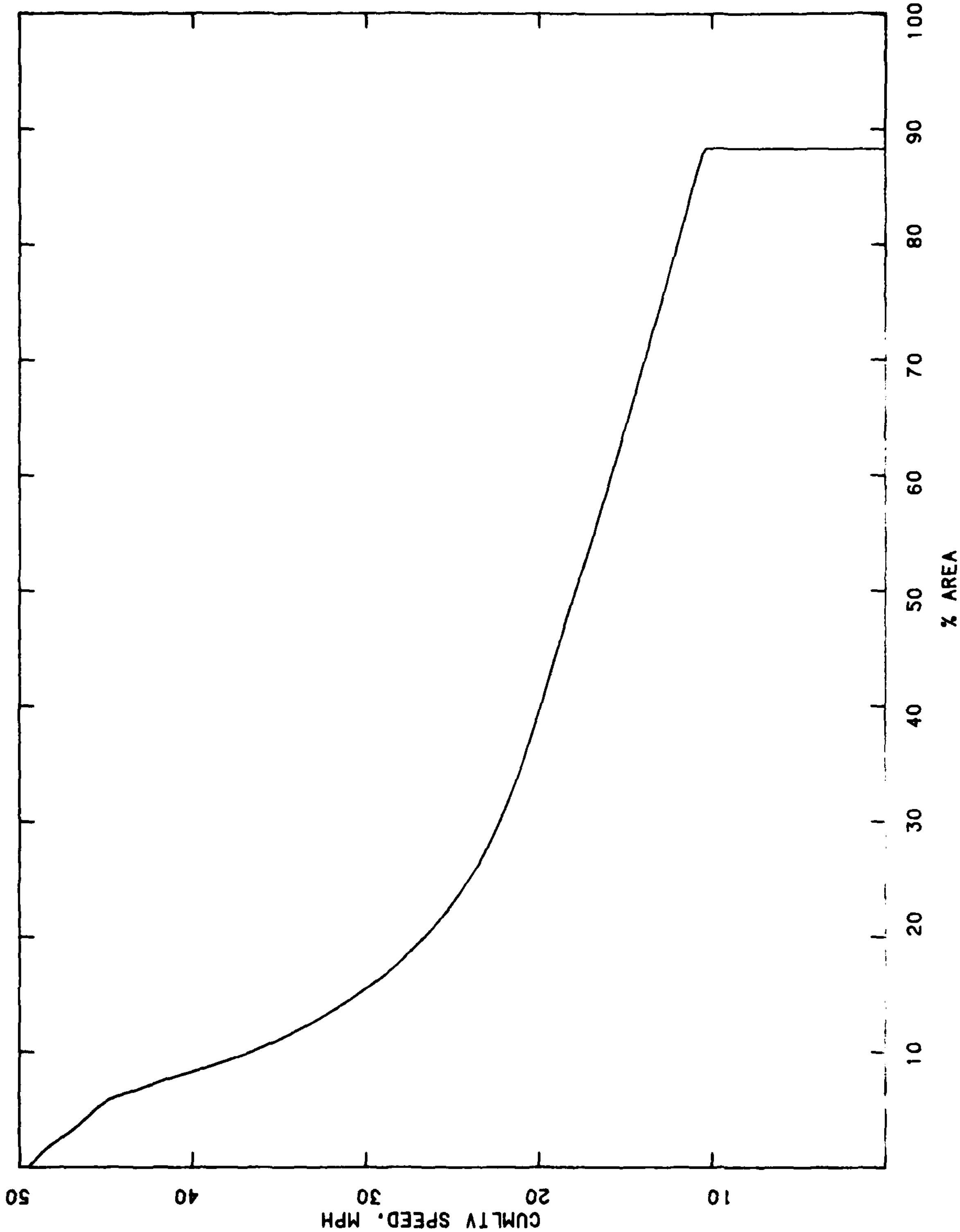
PERFORMANCE OF M151 W/AMM IN JORDAN WET



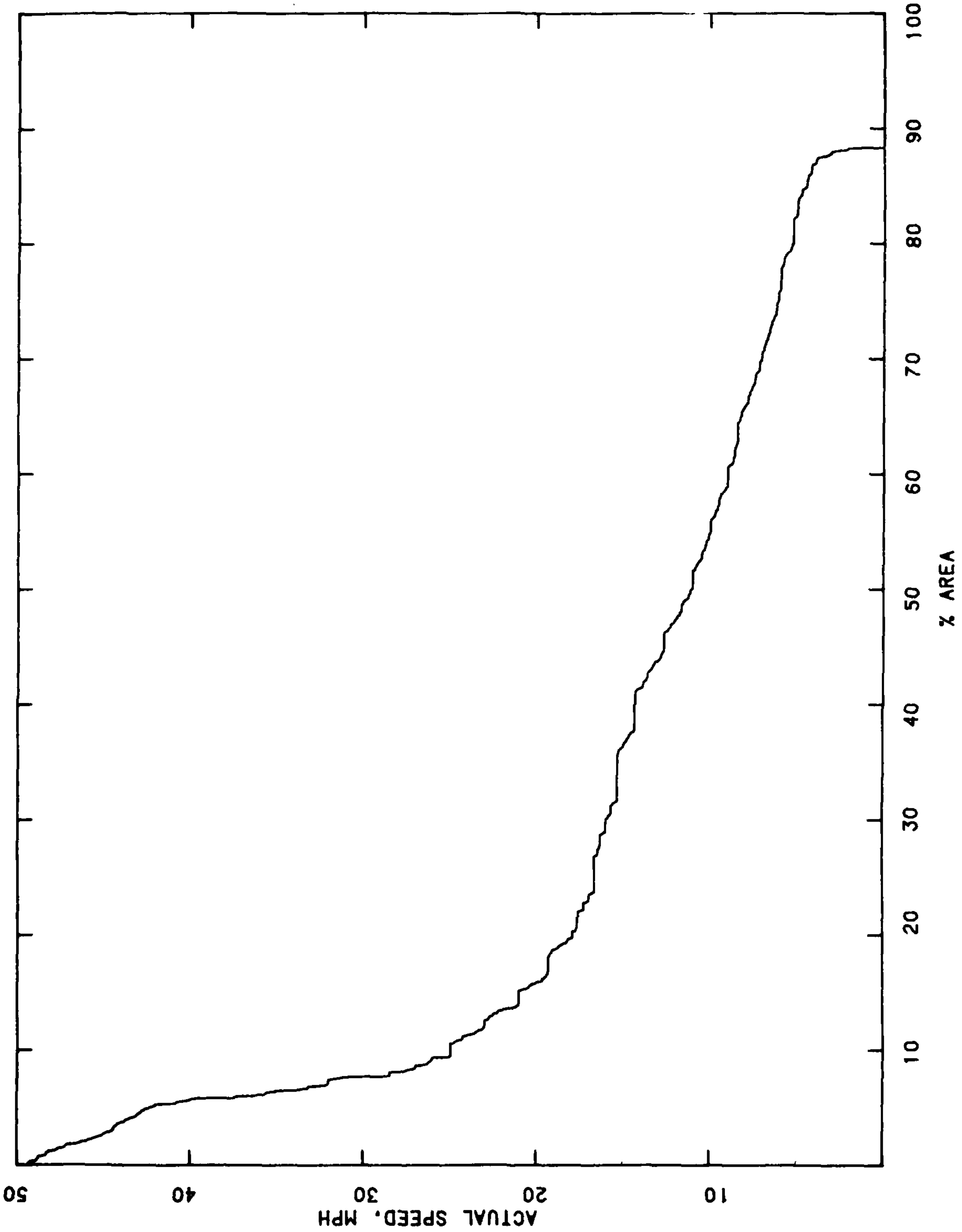
PERFORMANCE OF M151 W/AMM IN JORDAN WET



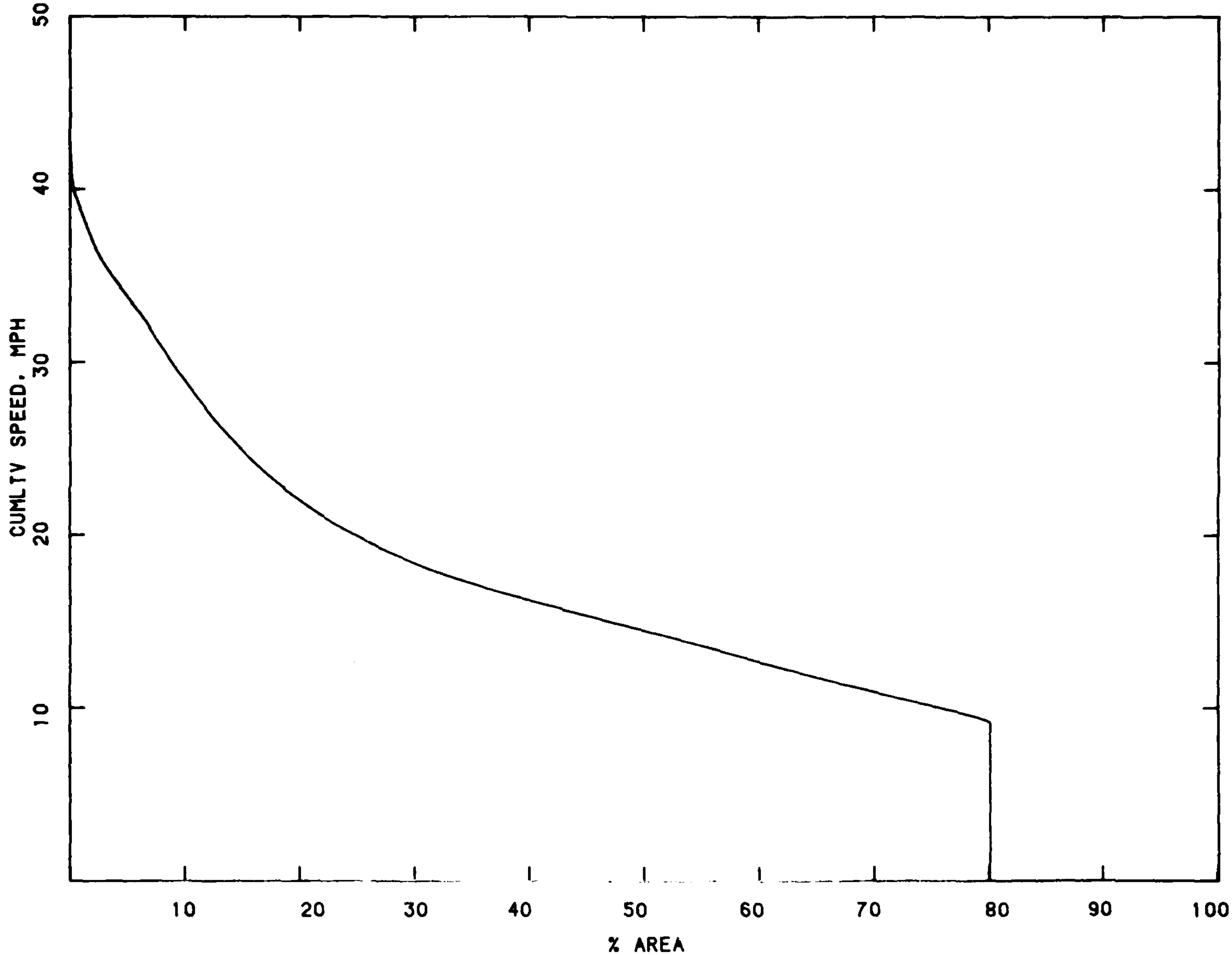
PERFORMANCE OF M151 A2 IN EUROPE1 DRY



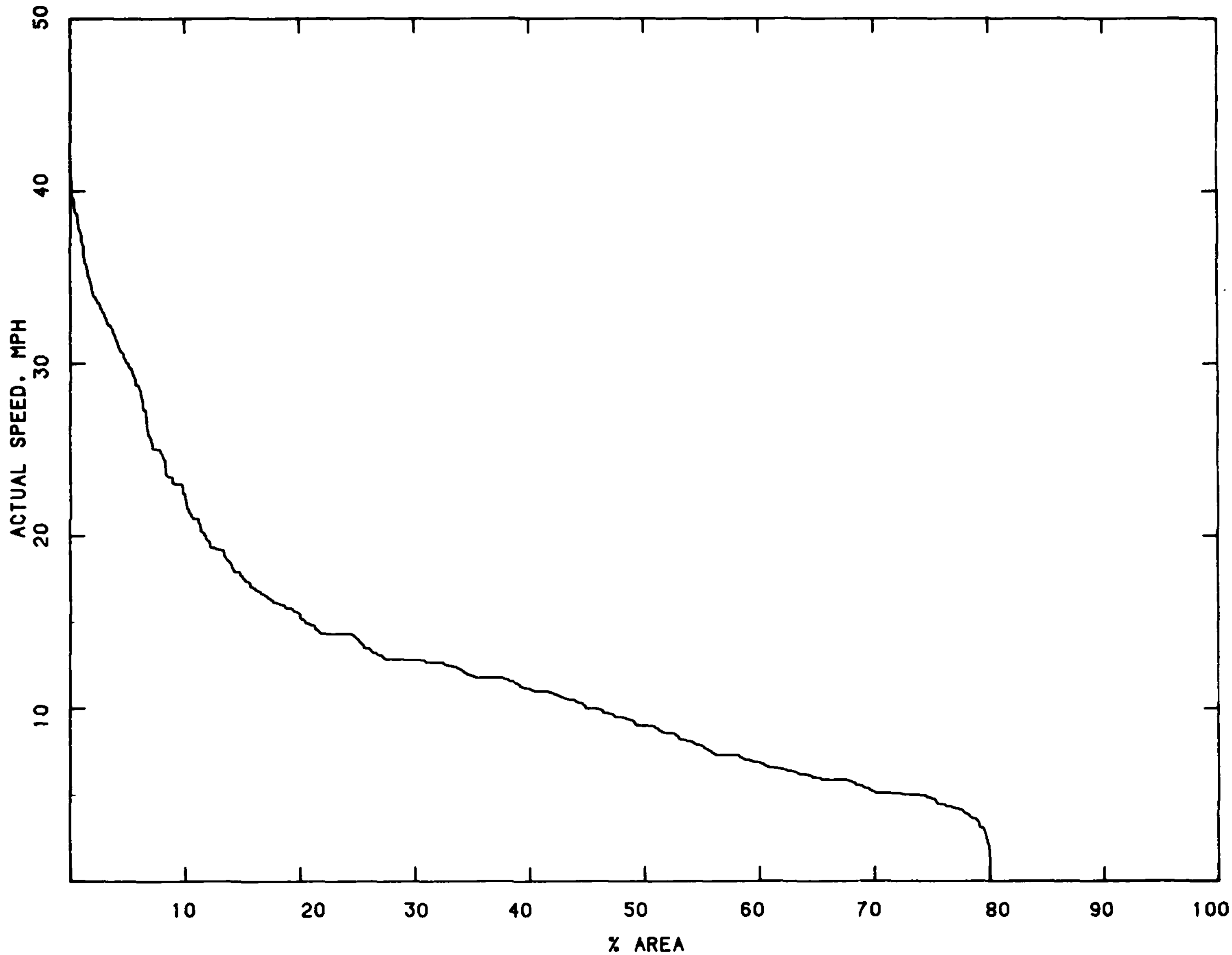
PERFORMANCE OF M151 A2 IN EUROPE1 DRY

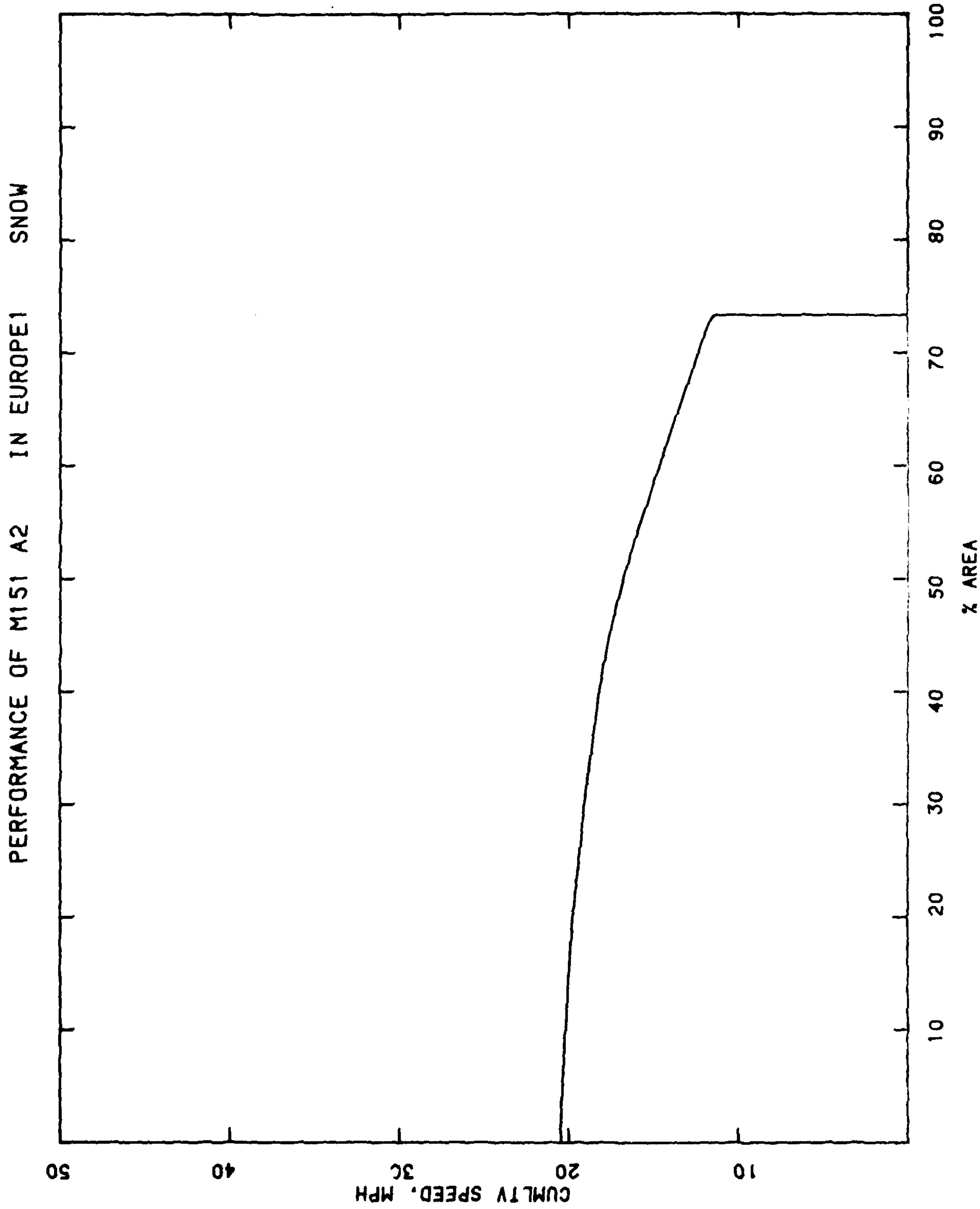


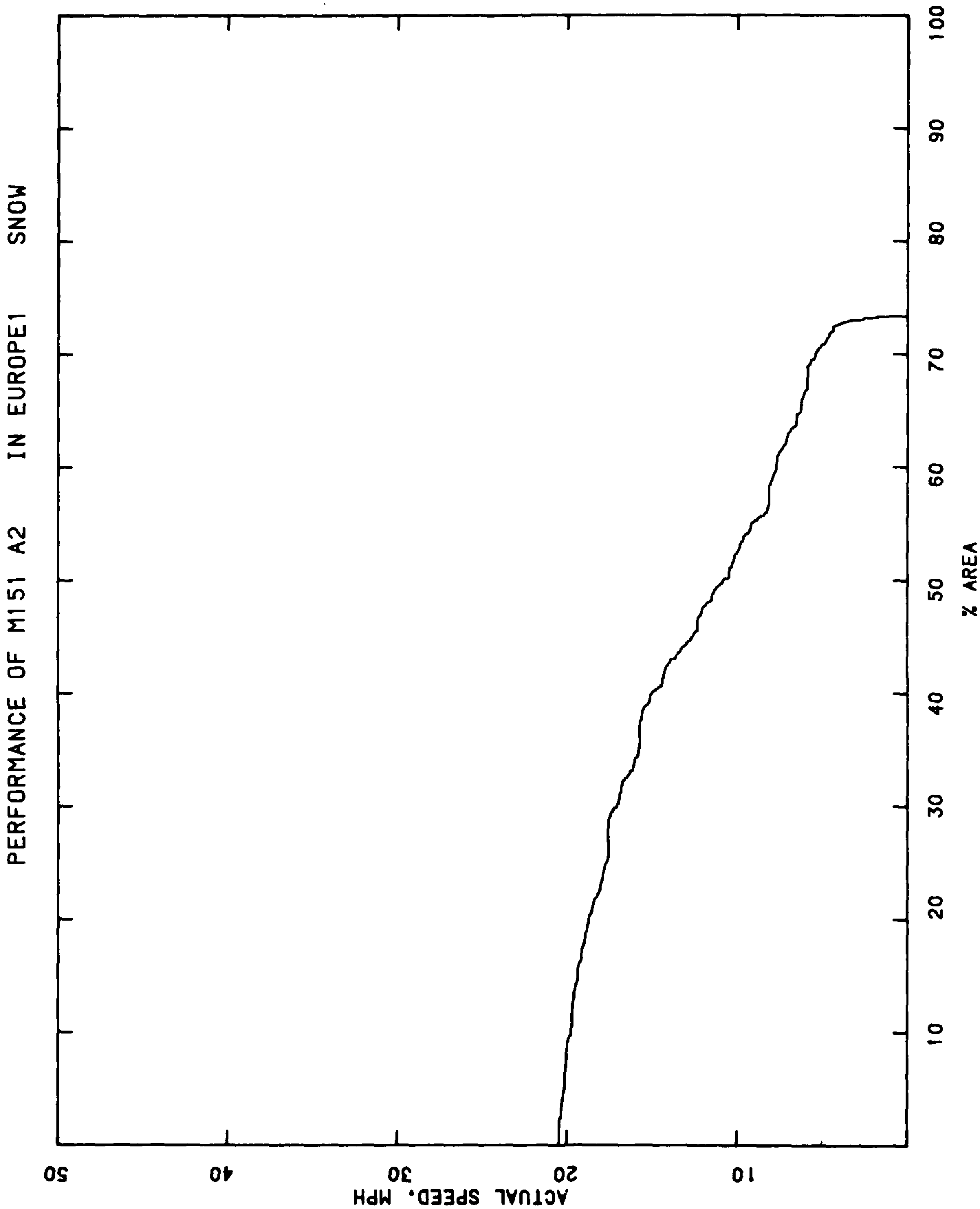
PERFORMANCE OF M151 A2 IN EUROPE1 WET



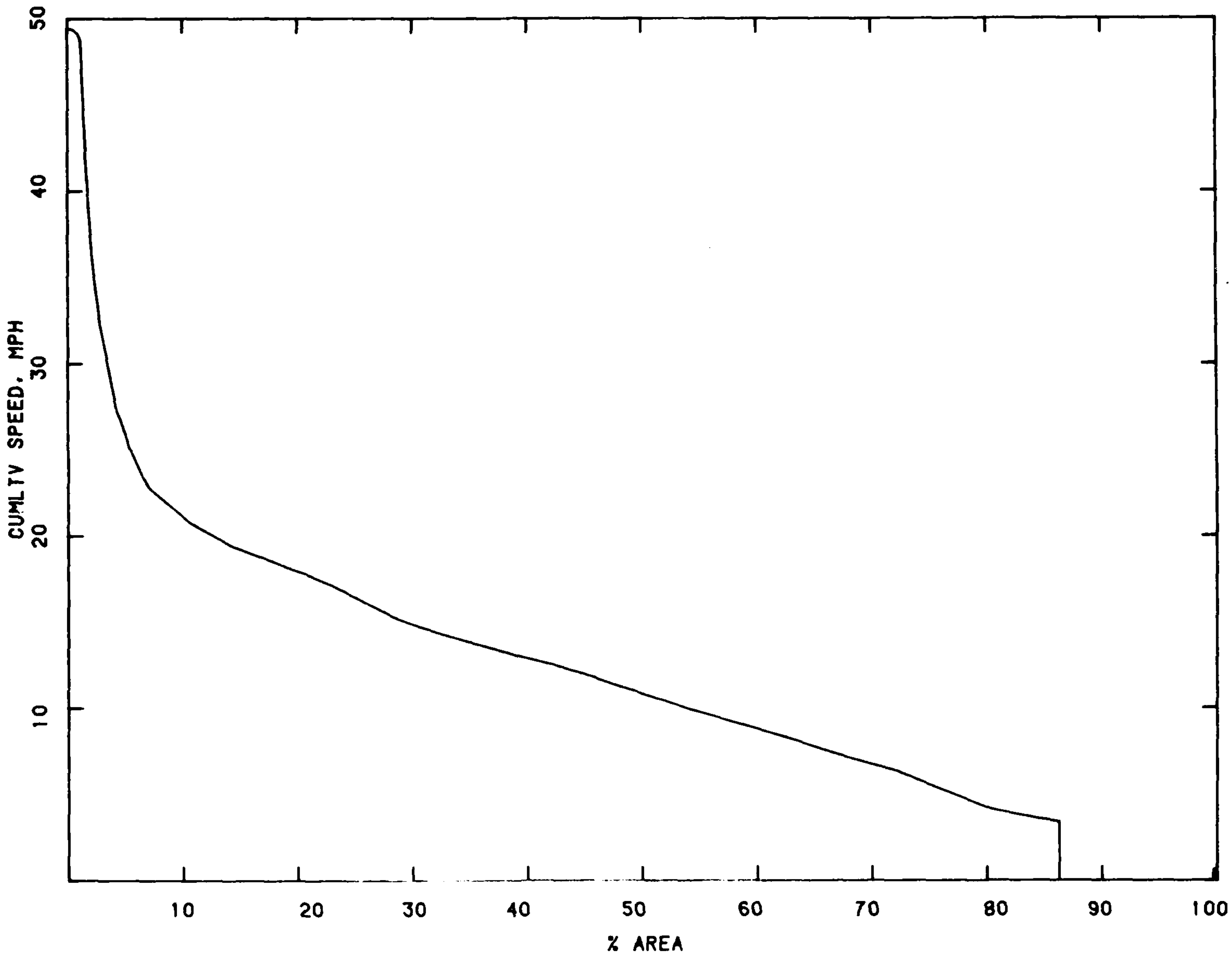
PERFORMANCE OF M151 A2 IN EUROPE1 WET

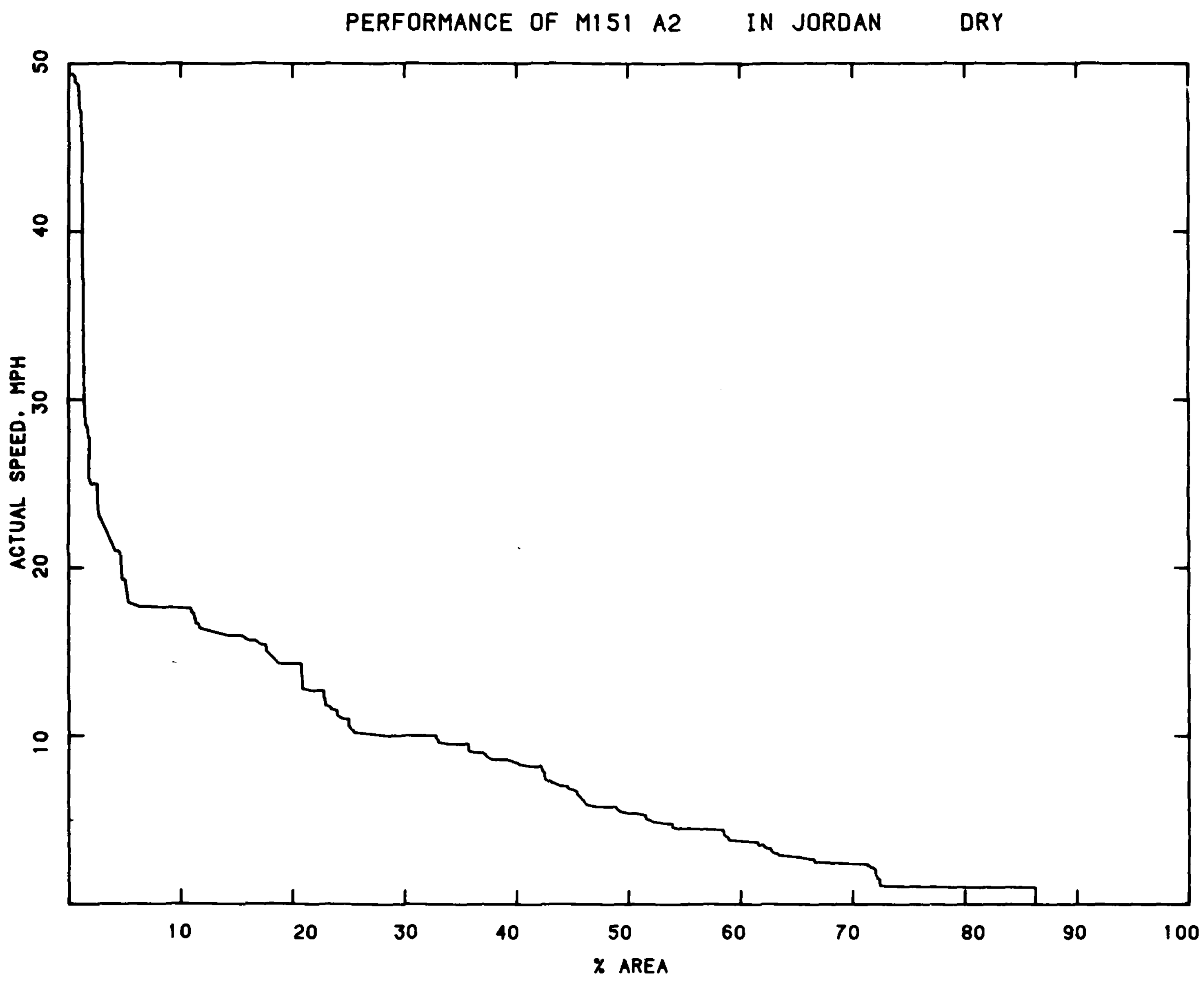



PERFORMANCE OF M151 A2 IN EUROPE1 SNOW
CUMLTV SPEED, MPH
50
40
3C
20
10
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF M151 A2 IN EUROPE1 SNOW
% AREA
10
20
30
40
50
60
70
80
90
100
ACTUAL SPEED, MPH
10
20
30
40
50

PERFORMANCE OF M151 A2 IN JORDAN DRY




PERFORMANCE OF M151 A2 IN JORDAN DRY
ACTUAL SPEED, MPH
50
40
30
20
10
10
20
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50
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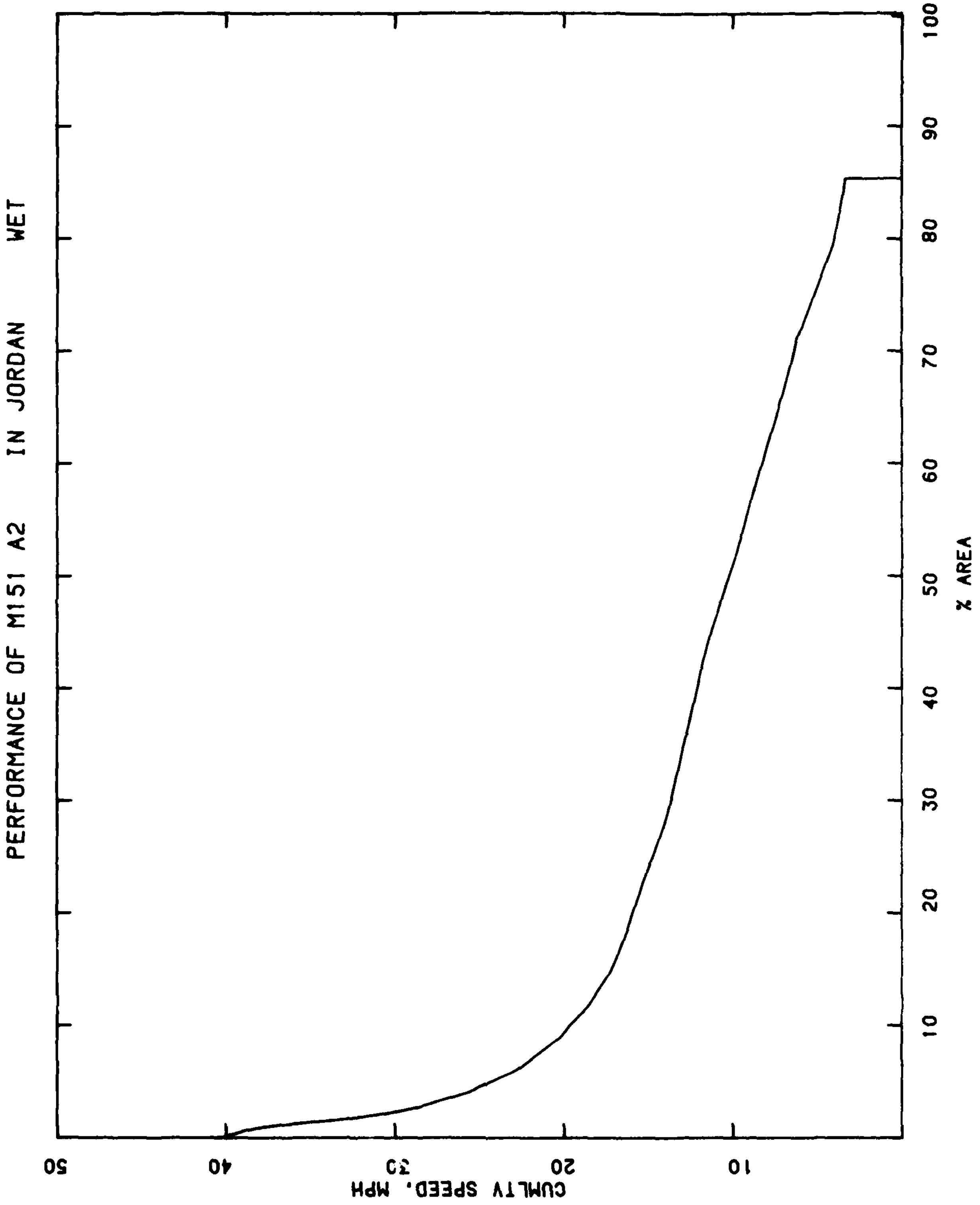
70
80
90
100
% AREA


PERFORMANCE OF M151 A2 IN JORDAN WET
CUMLTV SPEED, MPH
% AREA
50
40
30
20
10
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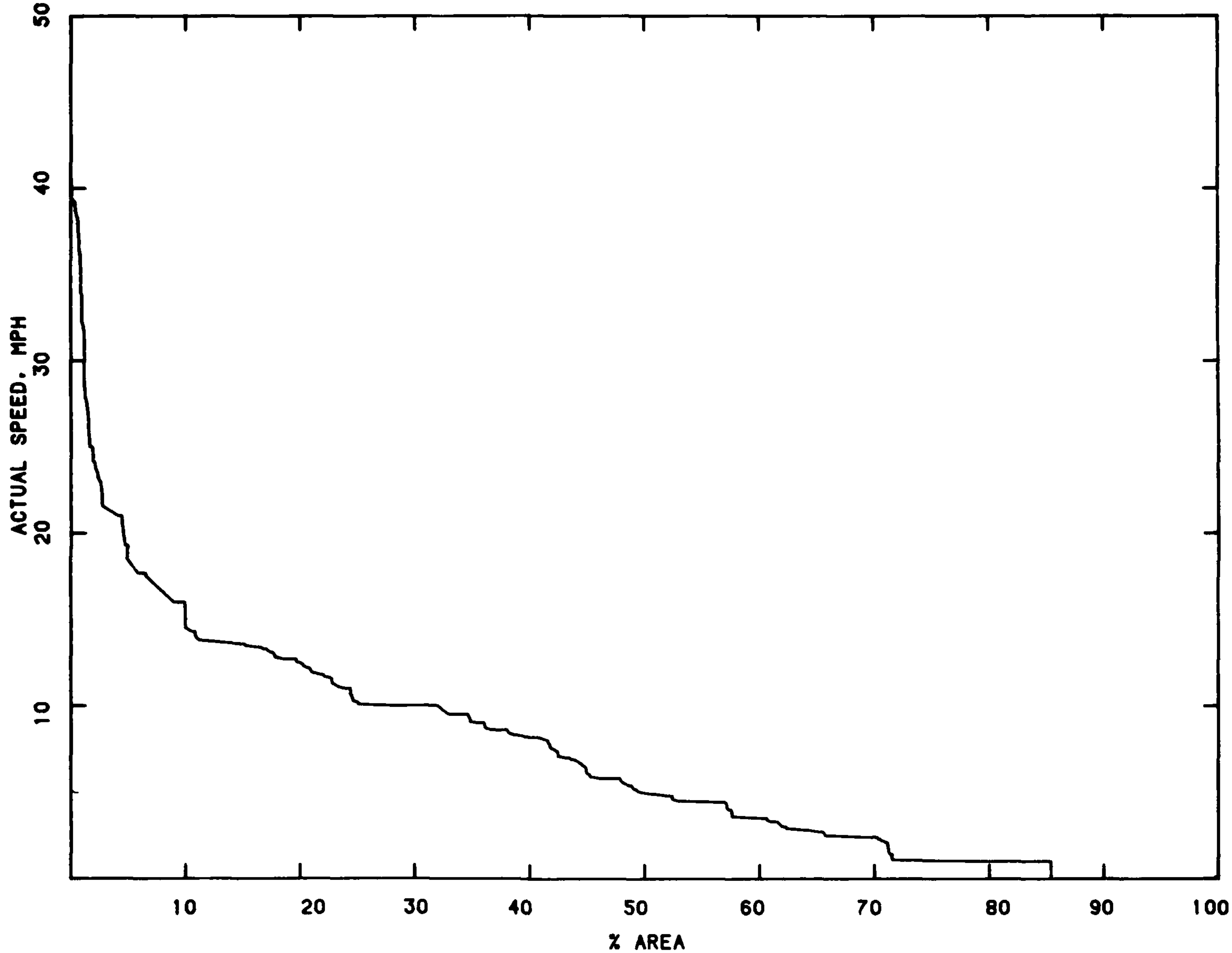
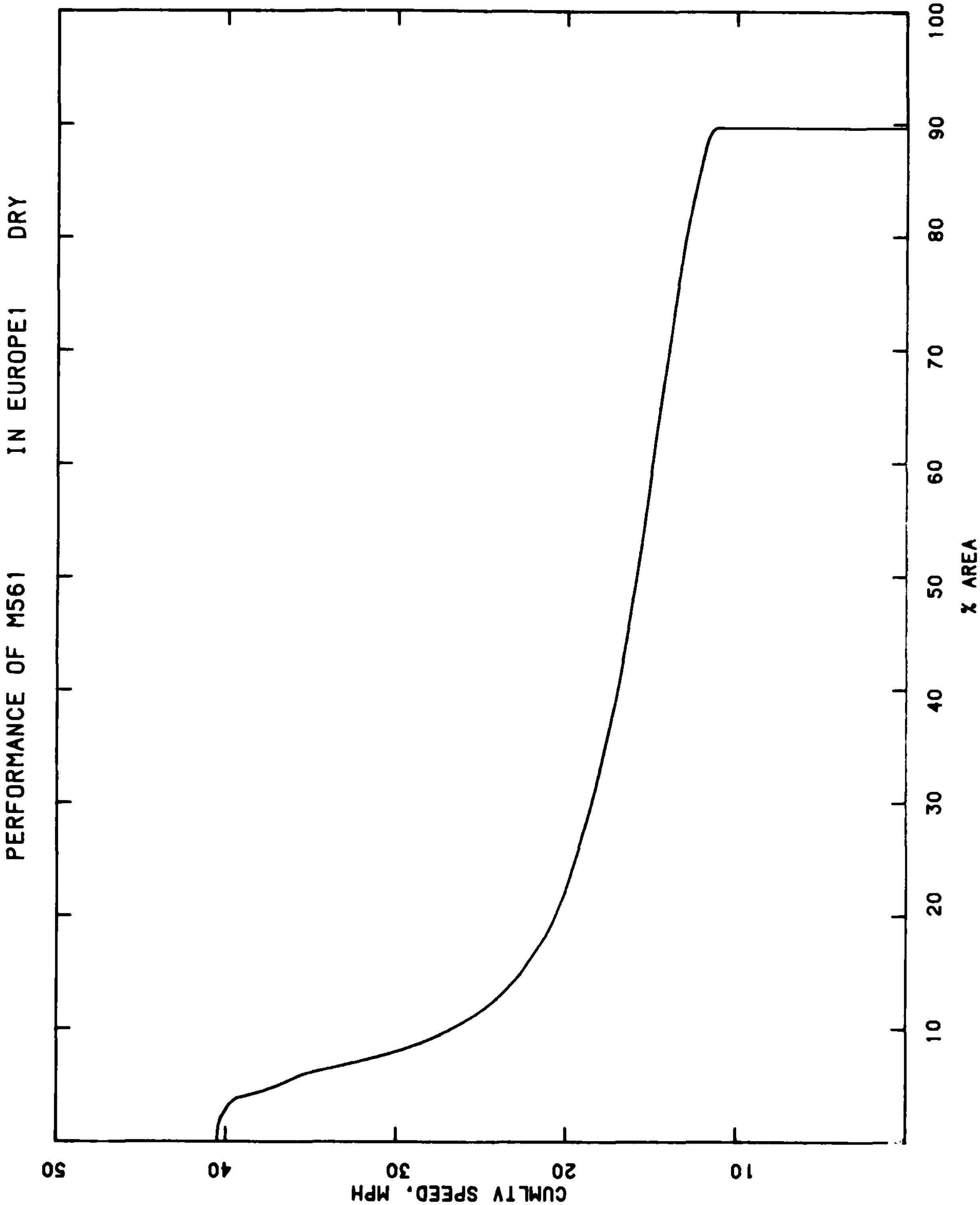
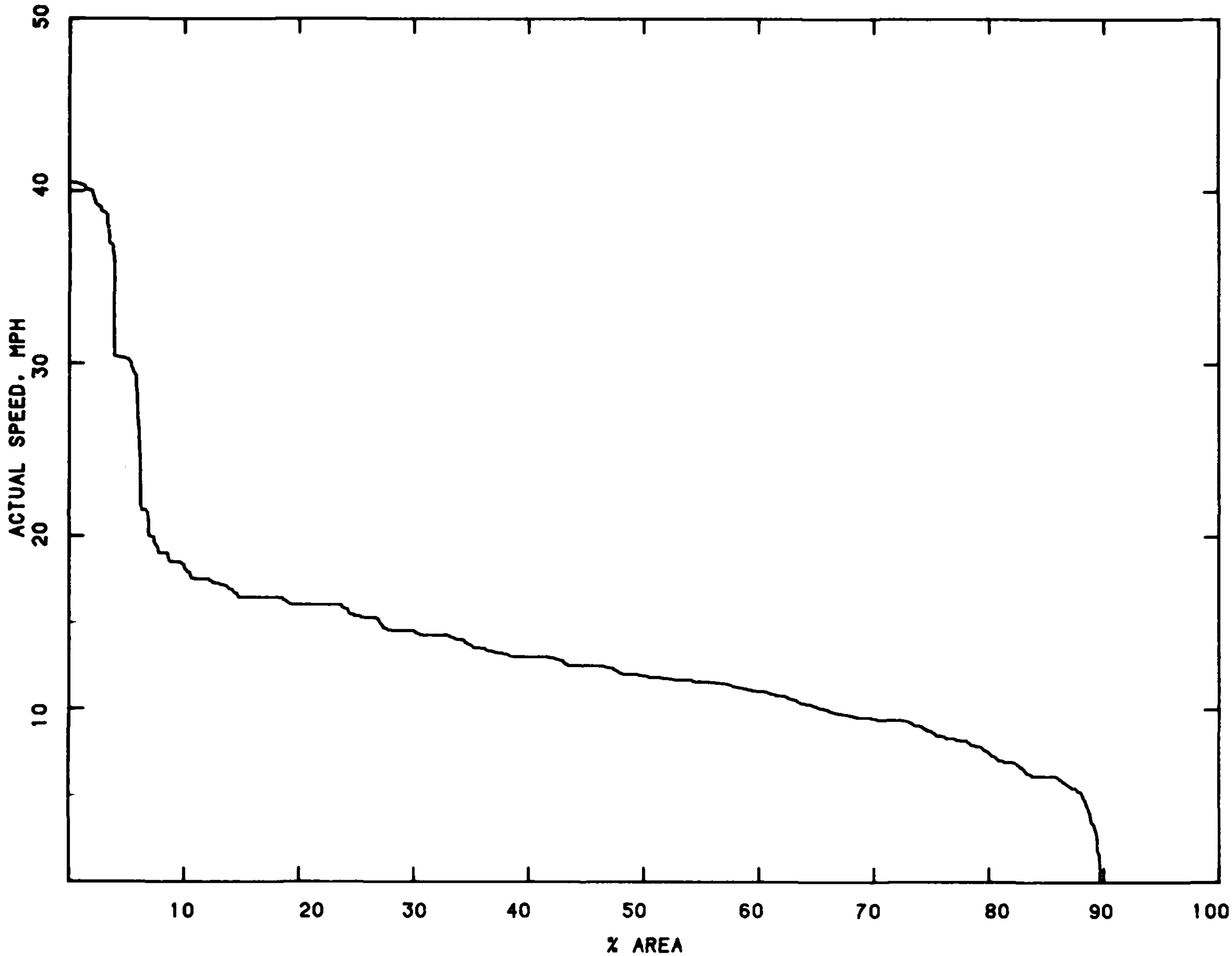
40
50
60
70
80
90
100

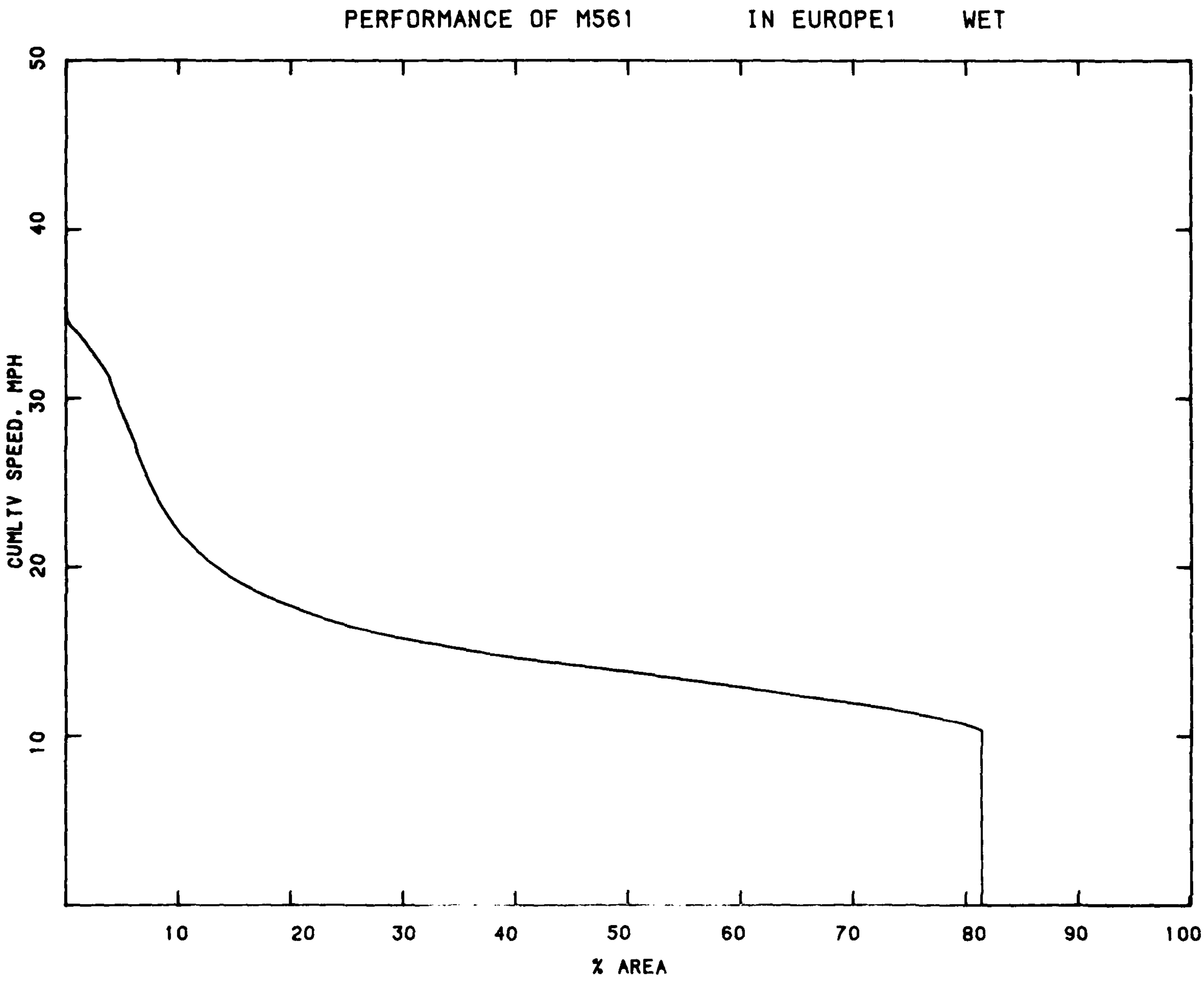
PERFORMANCE OF M151 A2 IN JORDAN WET




PERFORMANCE OF M561 IN EUROPE1 DRY
CUMLTV SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100

PERFORMANCE OF M561 IN EUROPE1 DRY





PERFORMANCE OF M561 IN EUROPE1 WET
CUMLTV SPEED, MPH
50
40
30
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10
10
20
30
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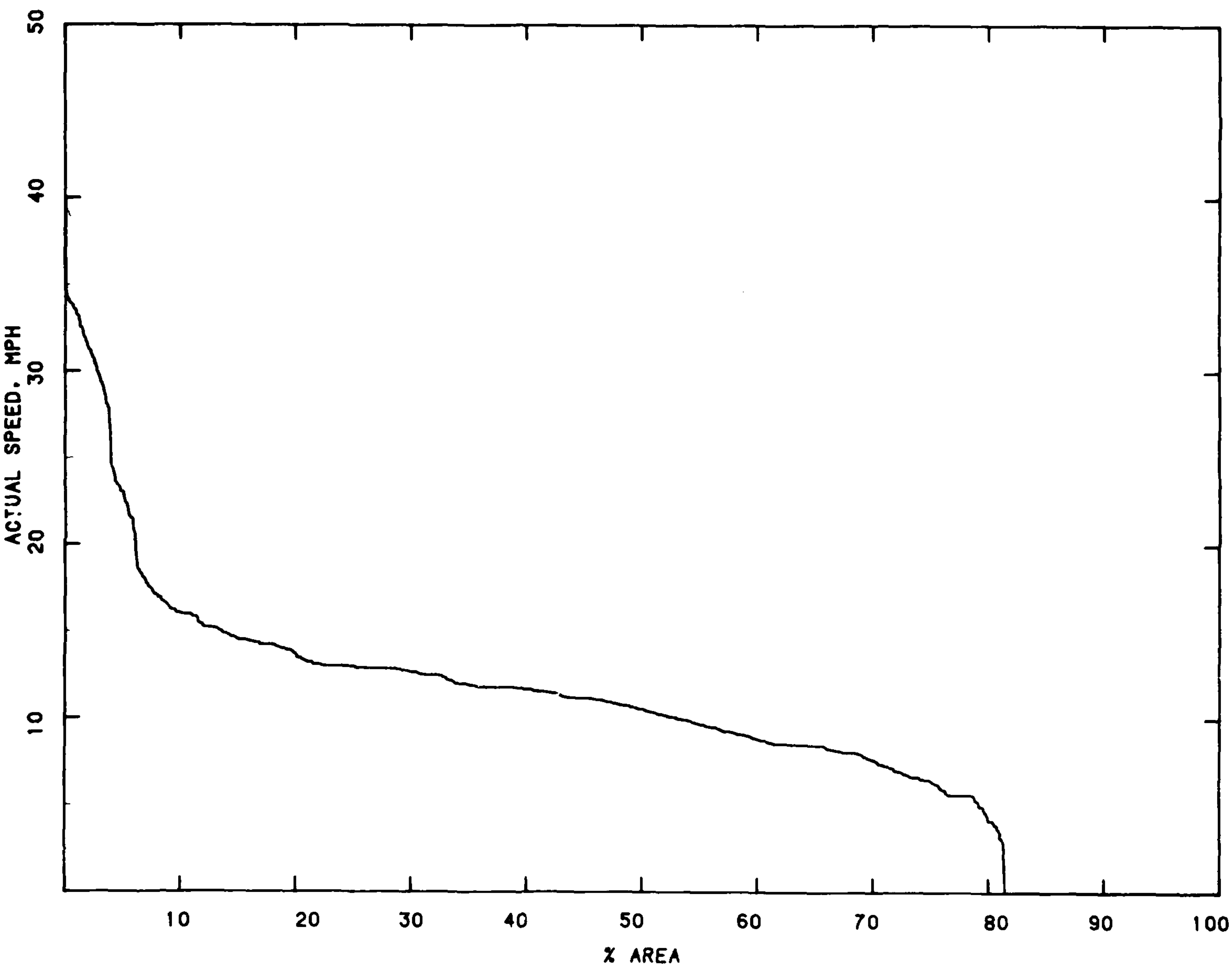
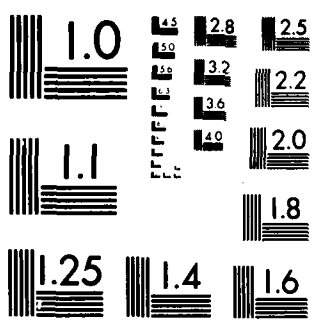
60
70
80
90
100
% AREA

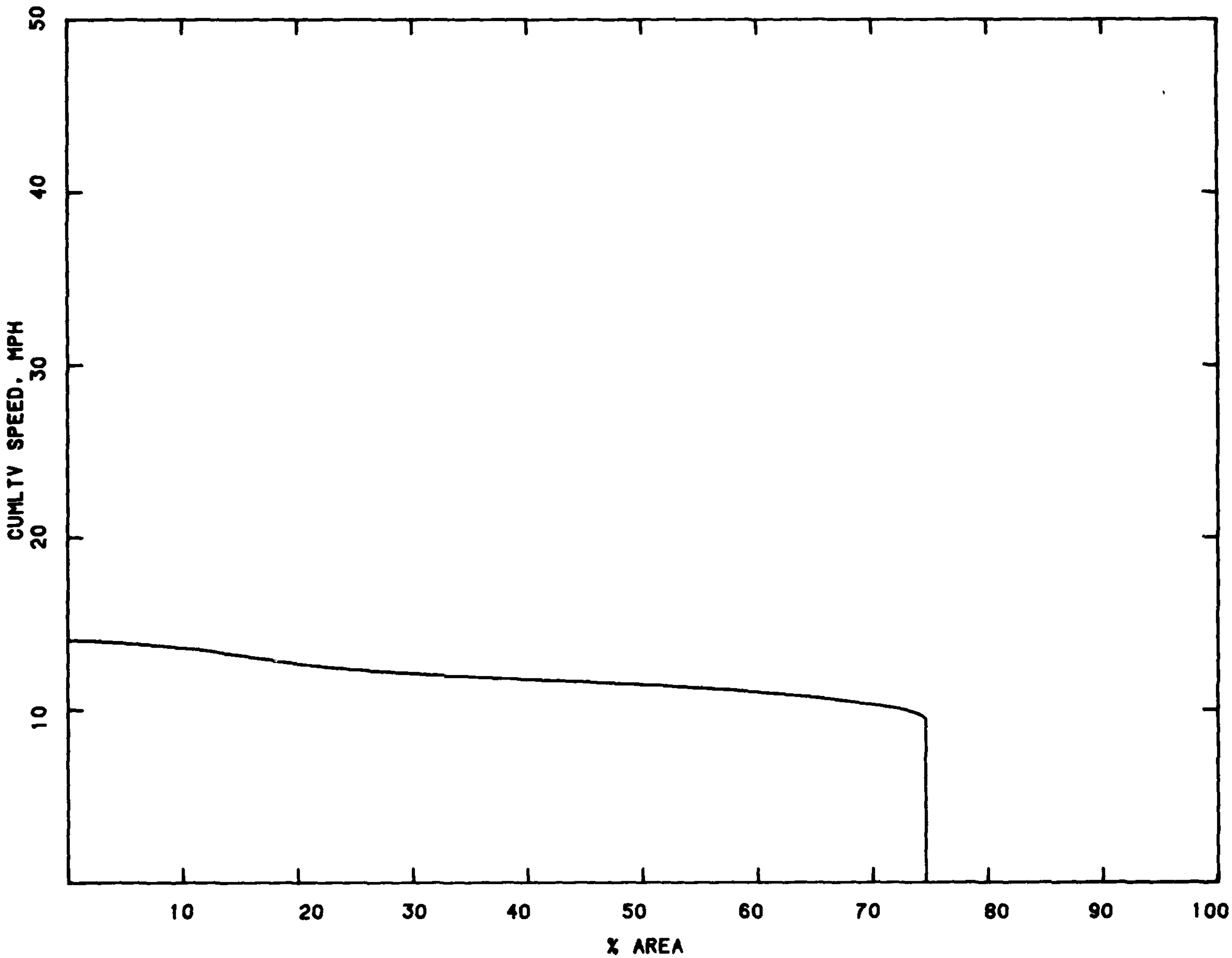
PERFORMANCE OF M561 IN EUROPE1 WET

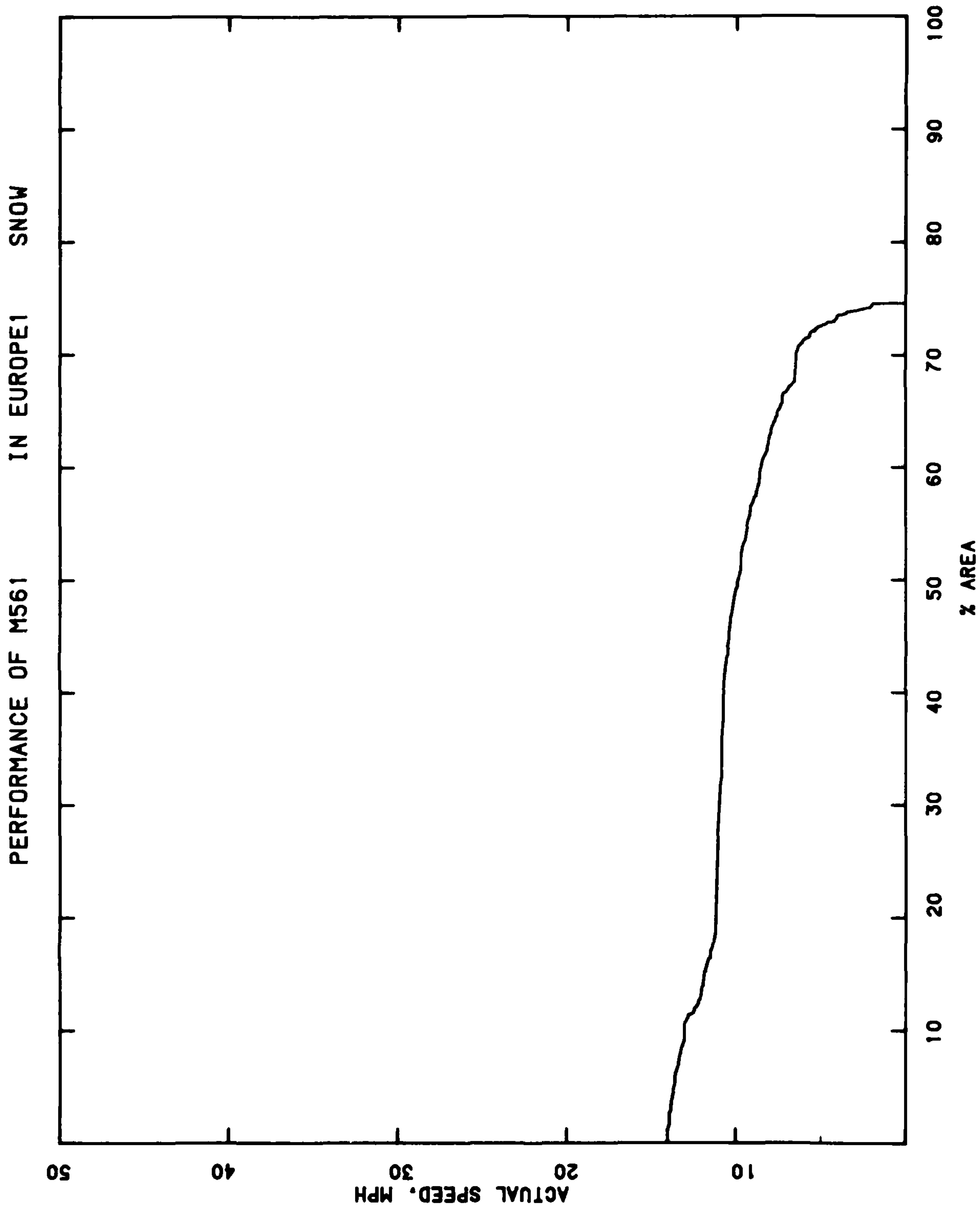




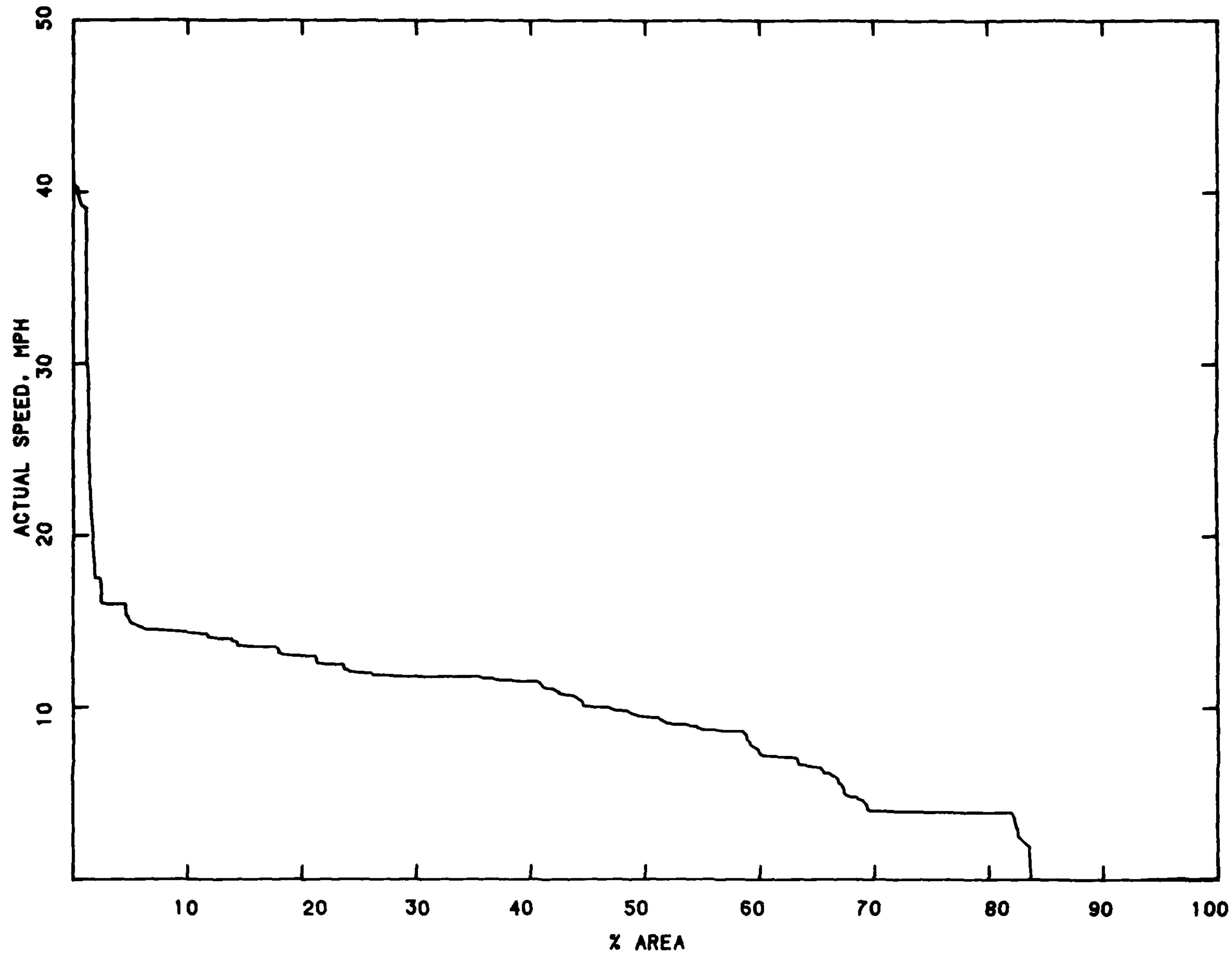
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PERFORMANCE OF M561 IN EUROPE1 SNOW

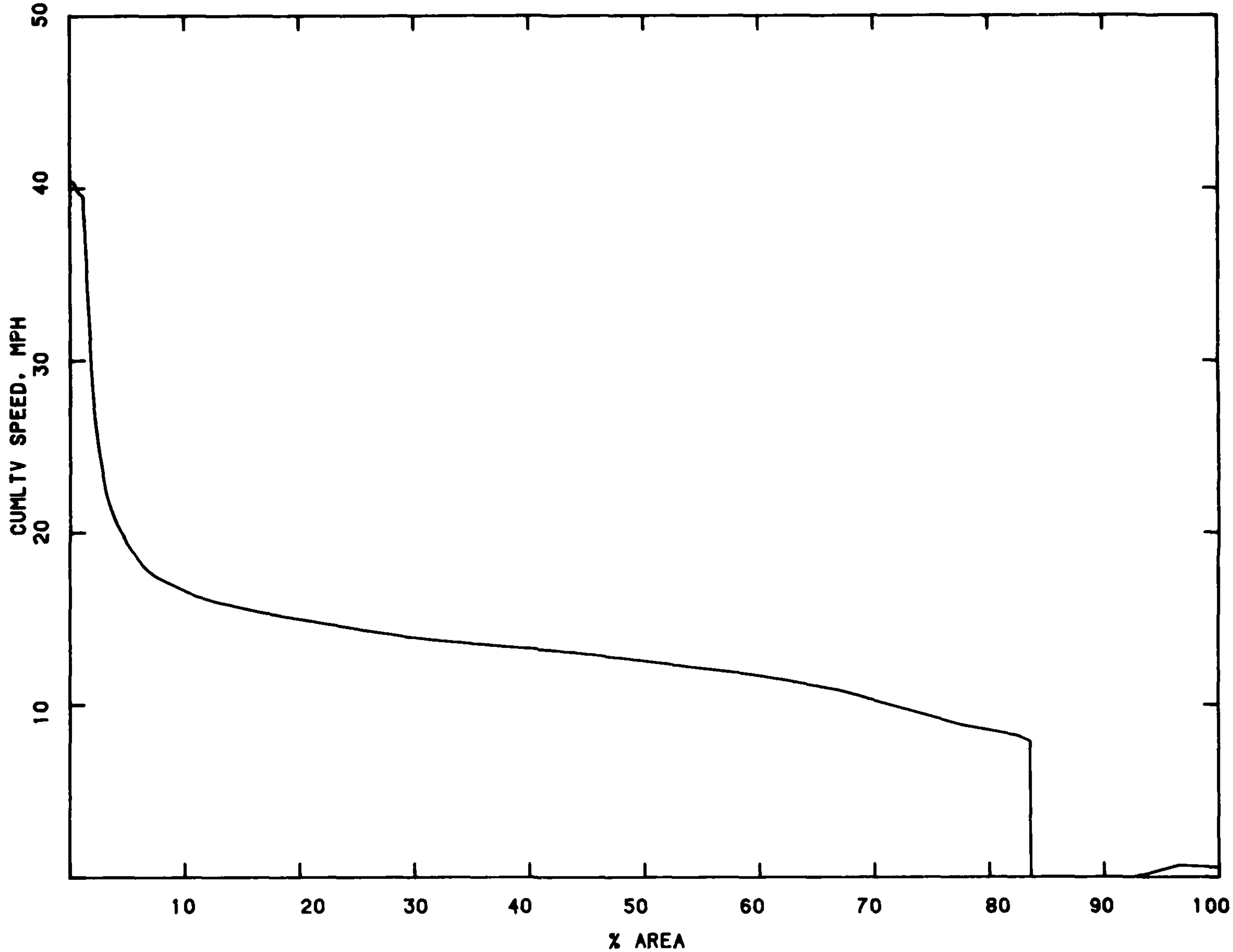



PERFORMANCE OF M561 IN EUROPE1 SNOW
ACTUAL SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100

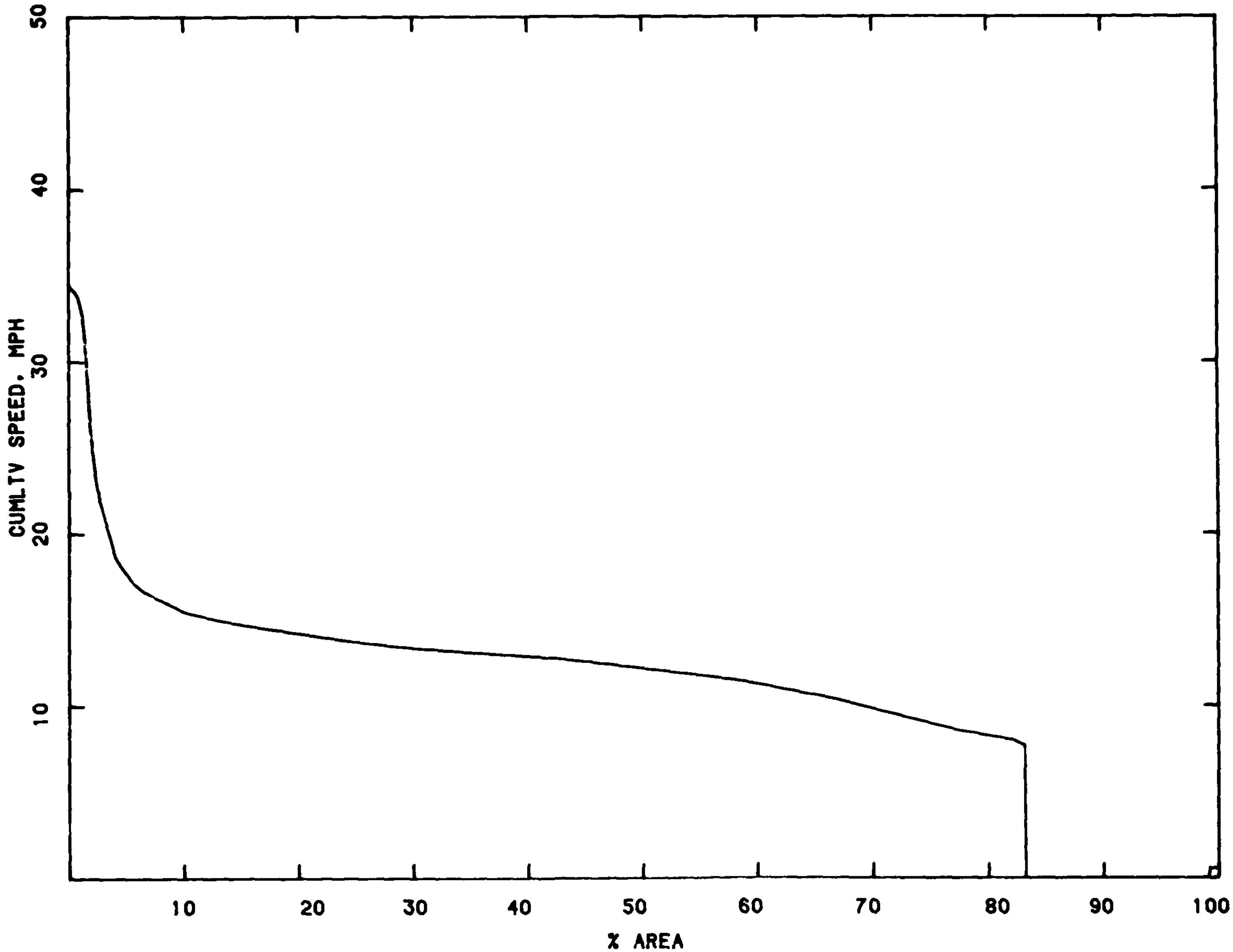
PERFORMANCE OF M561 IN JORDAN DRY



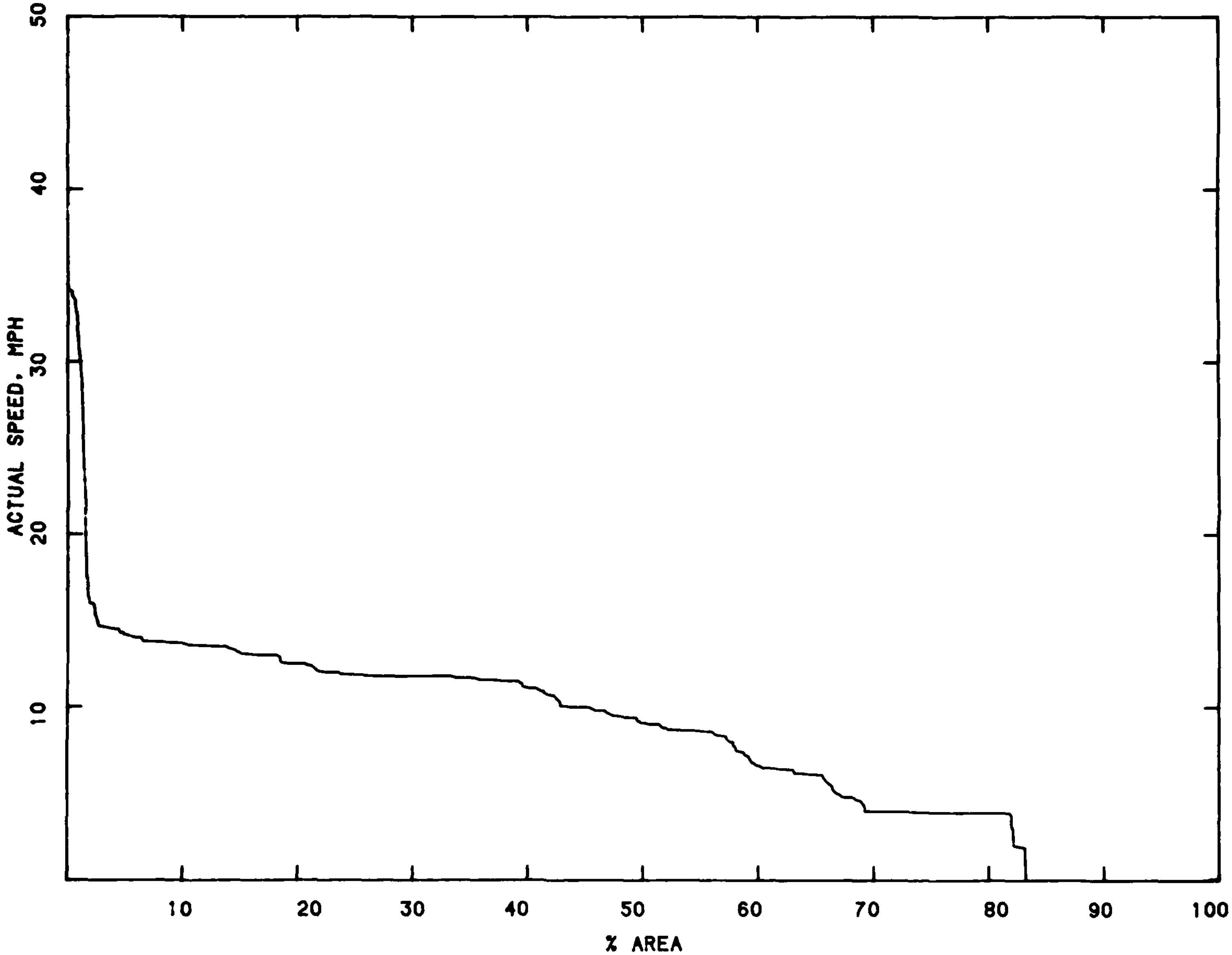
PERFORMANCE OF M561 IN JORDAN DRY



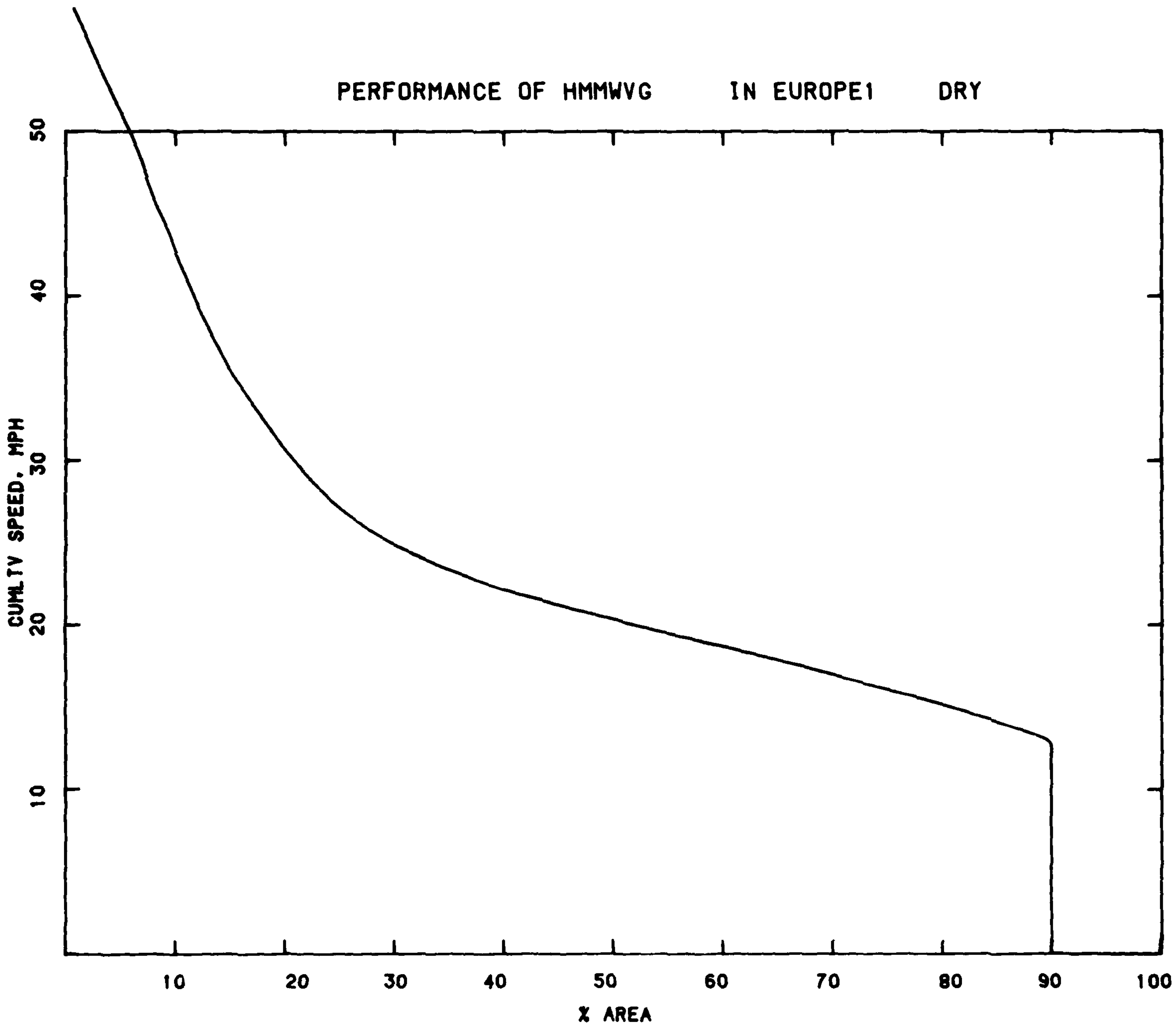
PERFORMANCE OF M561 IN JORDAN WET

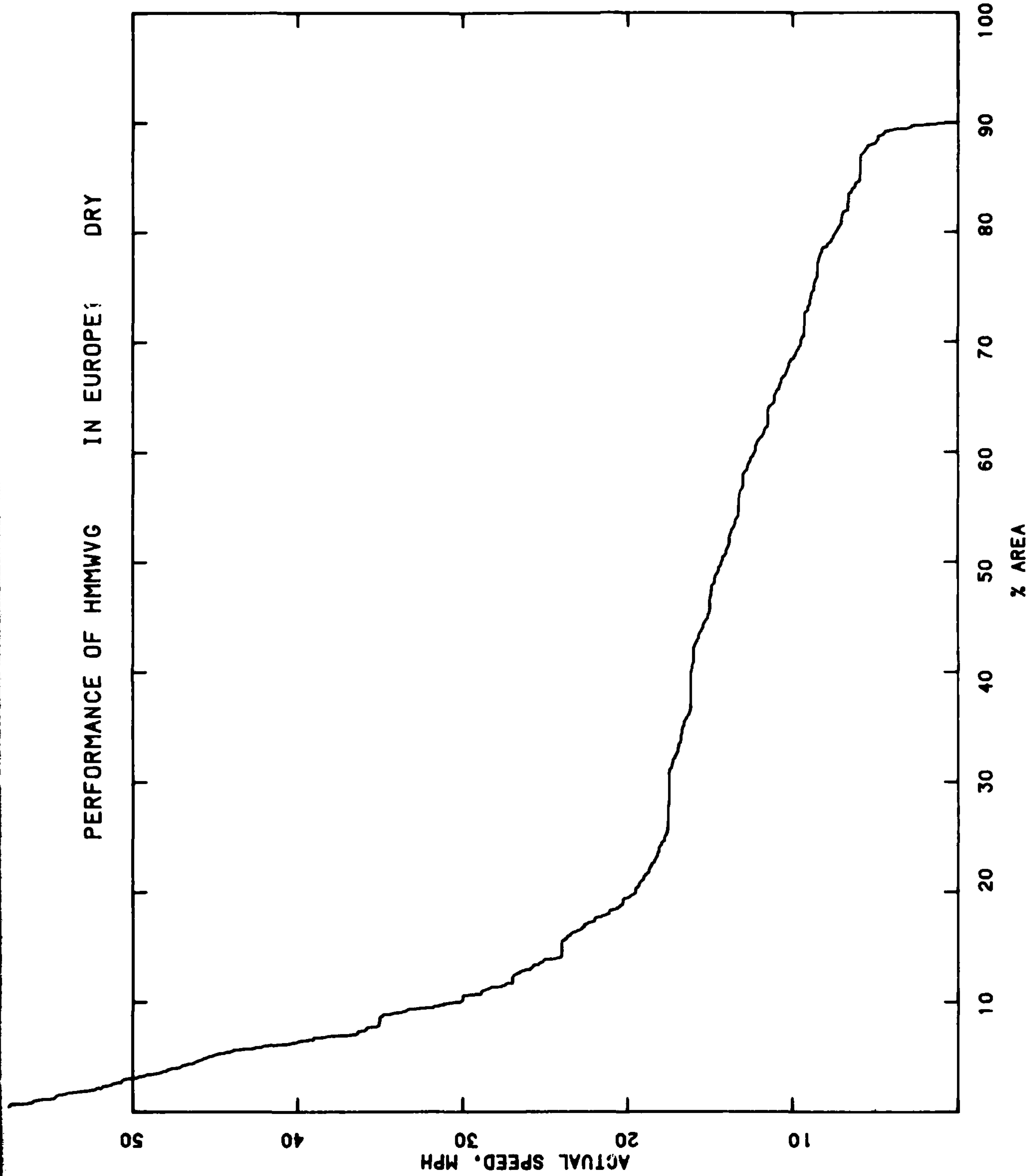


PERFORMANCE OF M561 IN JORDAN WET

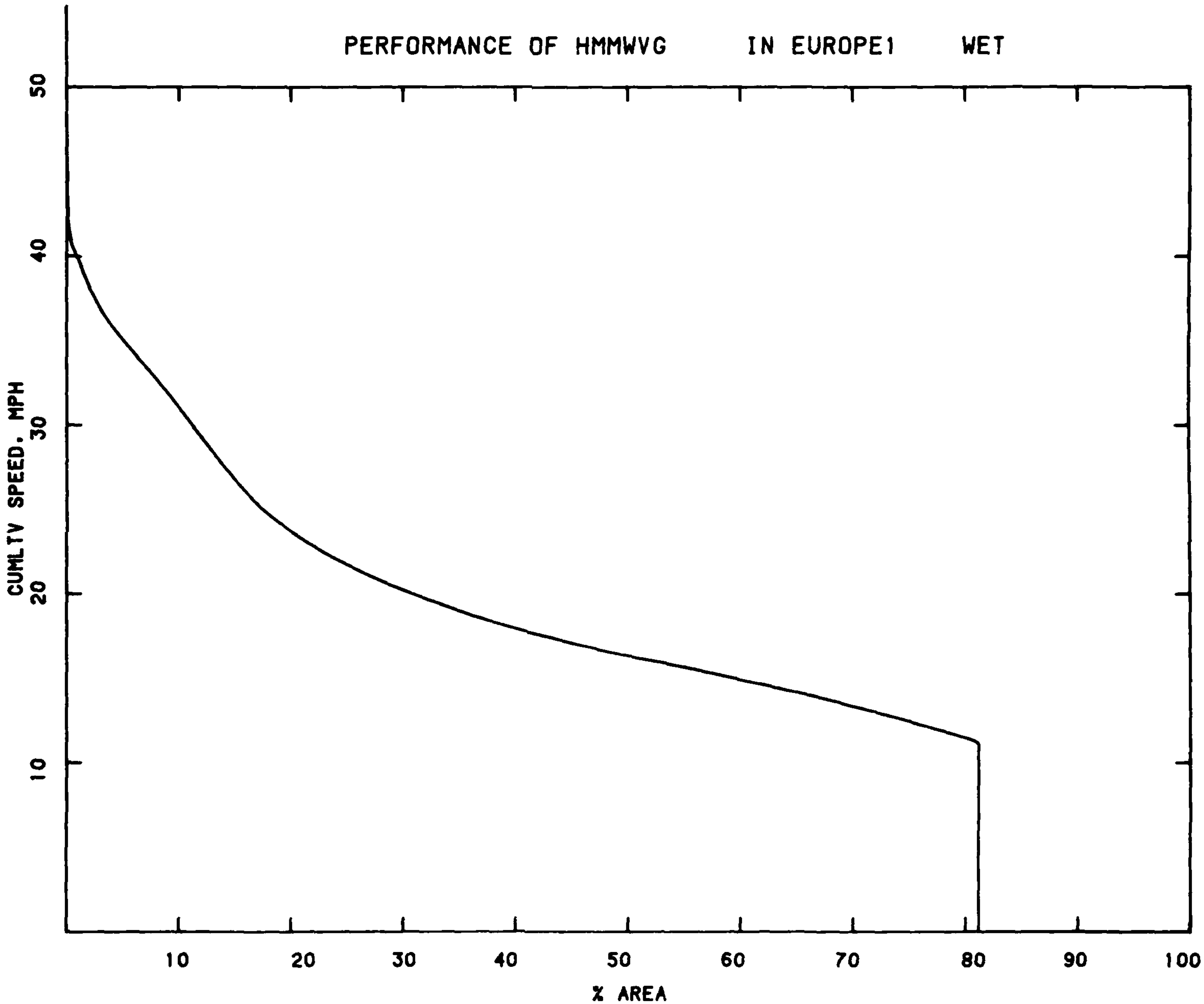


PERFORMANCE OF HMMWVG IN EUROPE1 DRY

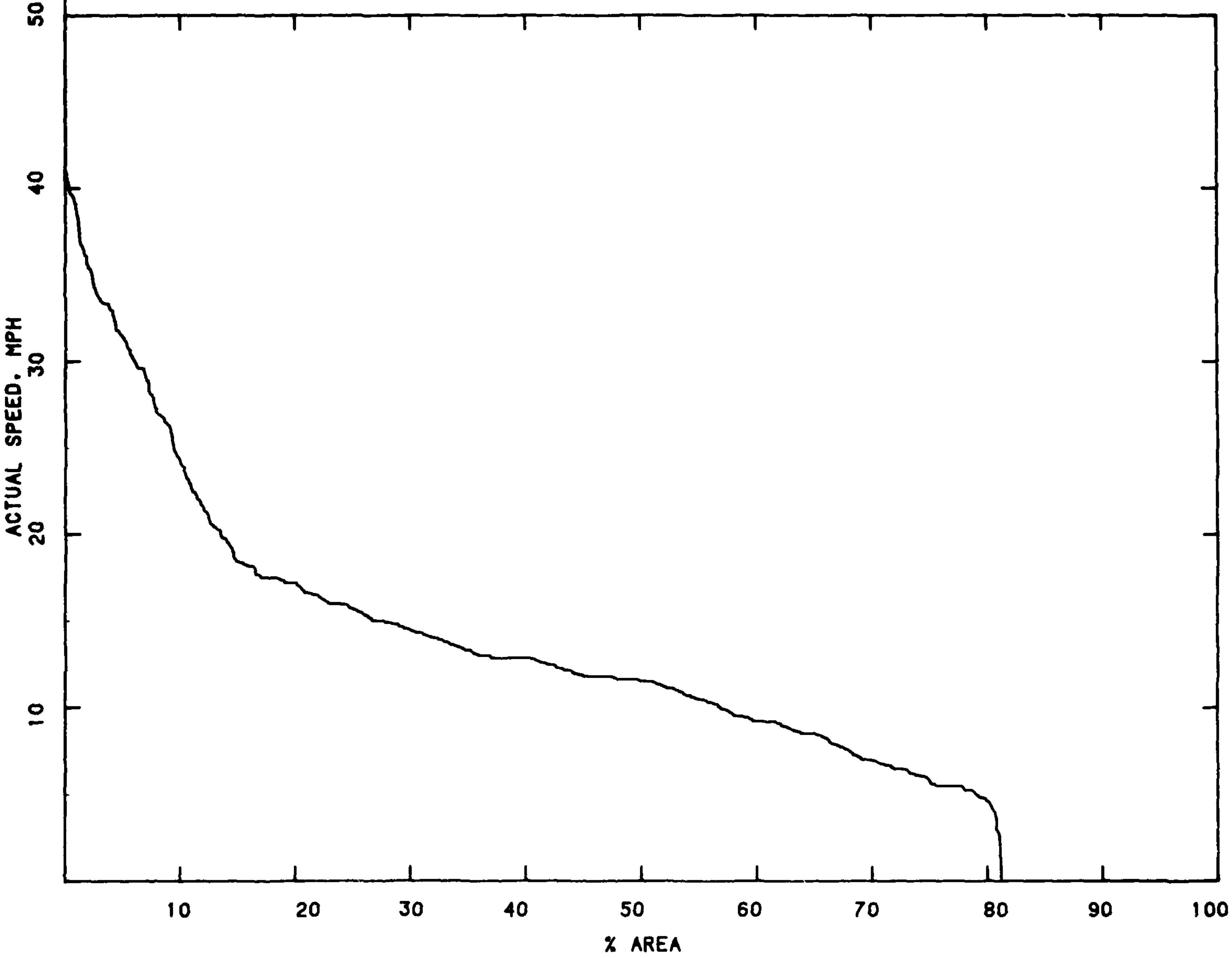


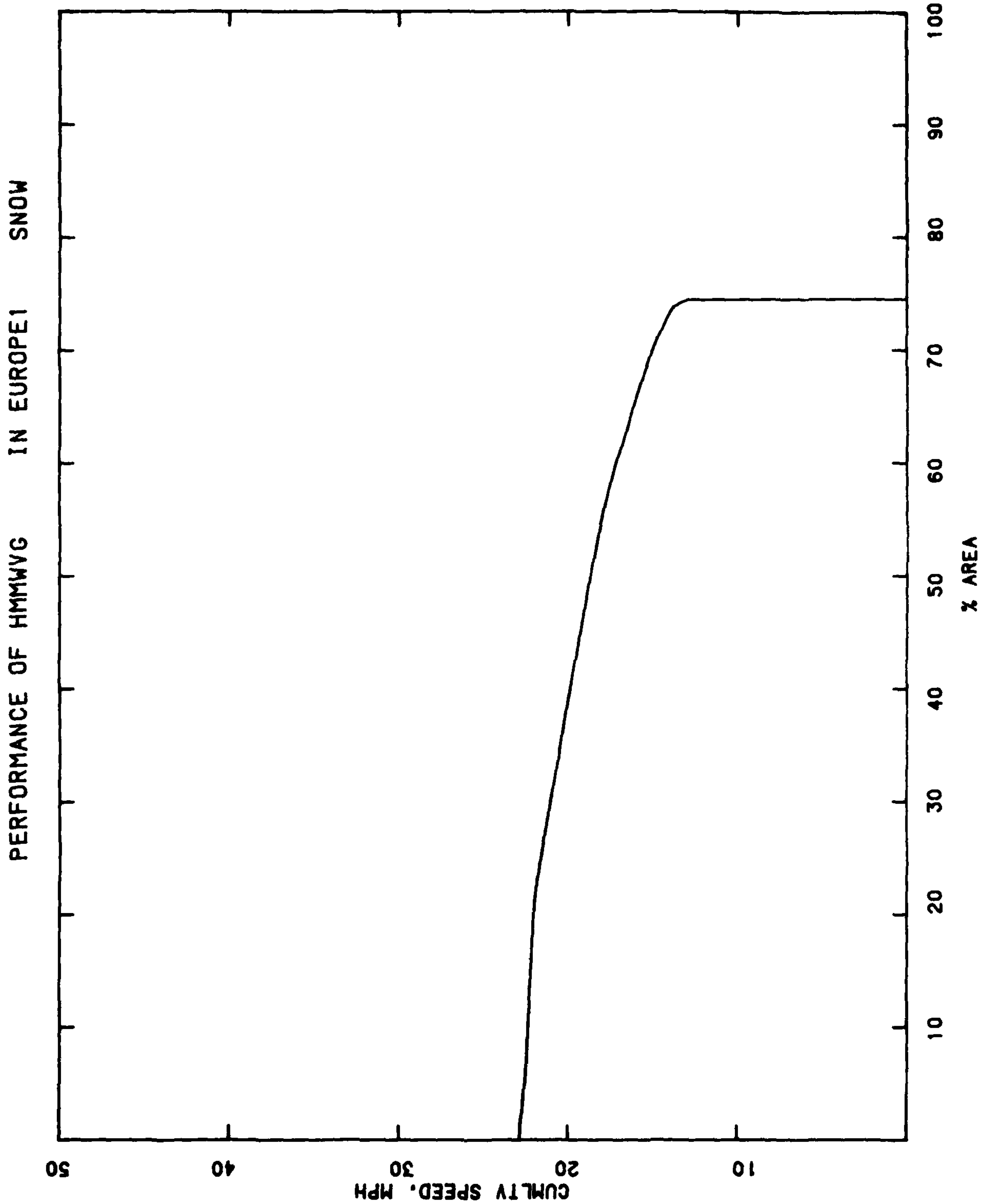

PERFORMANCE OF HMMWVG IN EUROPE: DRY
ACTUAL SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100

PERFORMANCE OF HMMWVG IN EUROPE1 WET

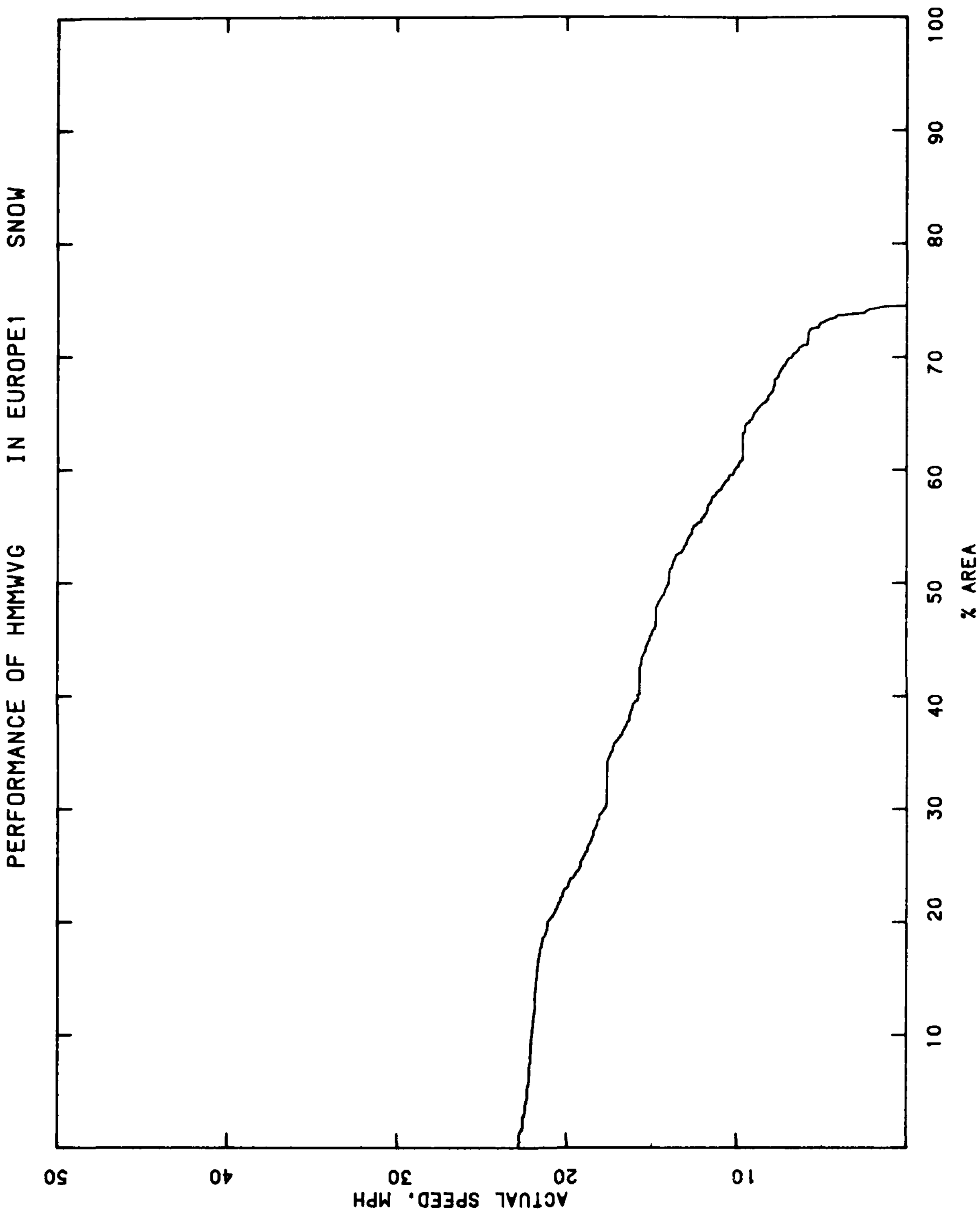


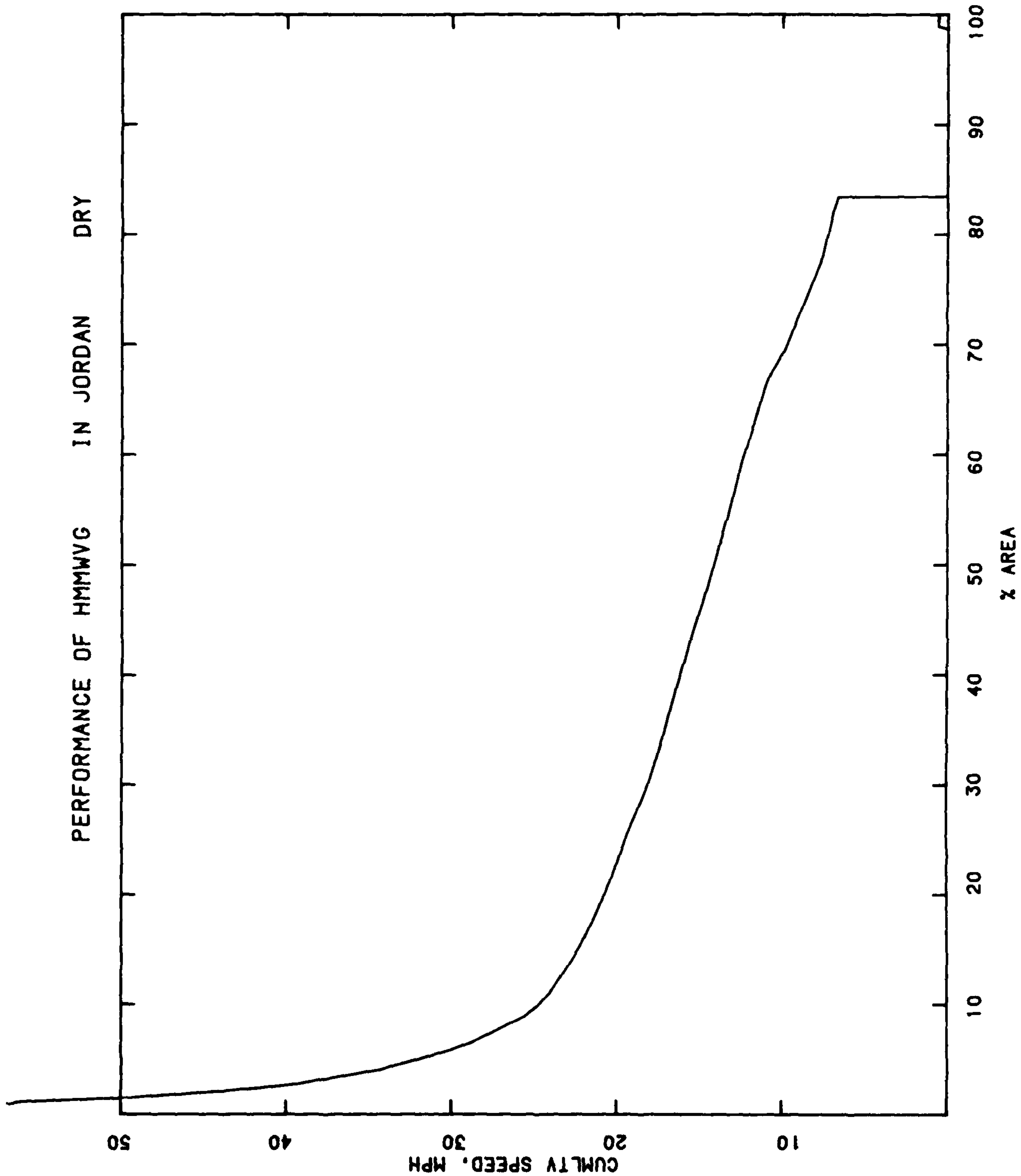
PERFORMANCE OF HMMWVG IN EUROPE1 WET



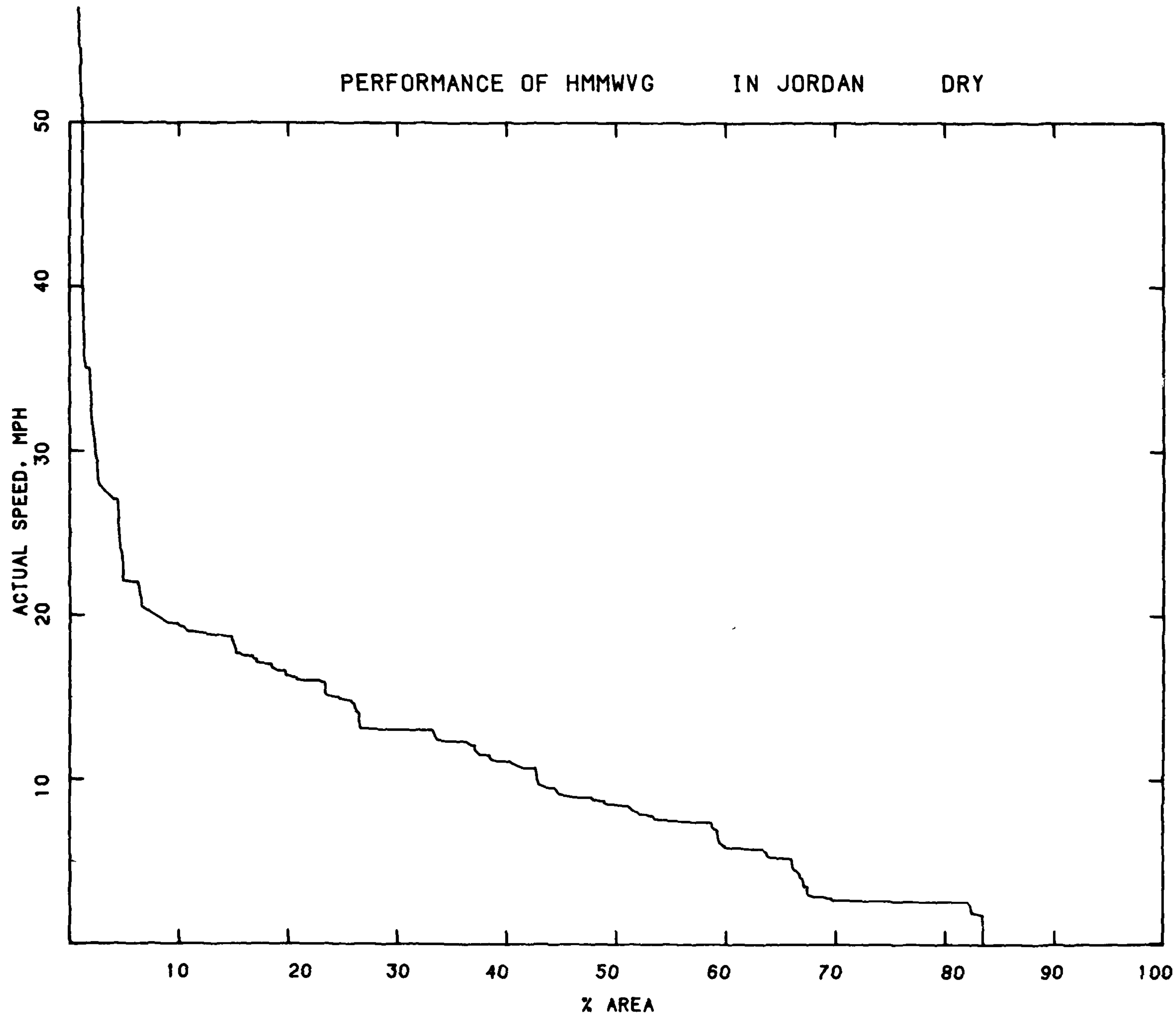


PERFORMANCE OF HMMWVG IN EUROPE1 SNOW
CUMLTY SPEED, MPH
50
40
30
20
10
% AREA
10
20
30
40
50
60
70
80
90
100

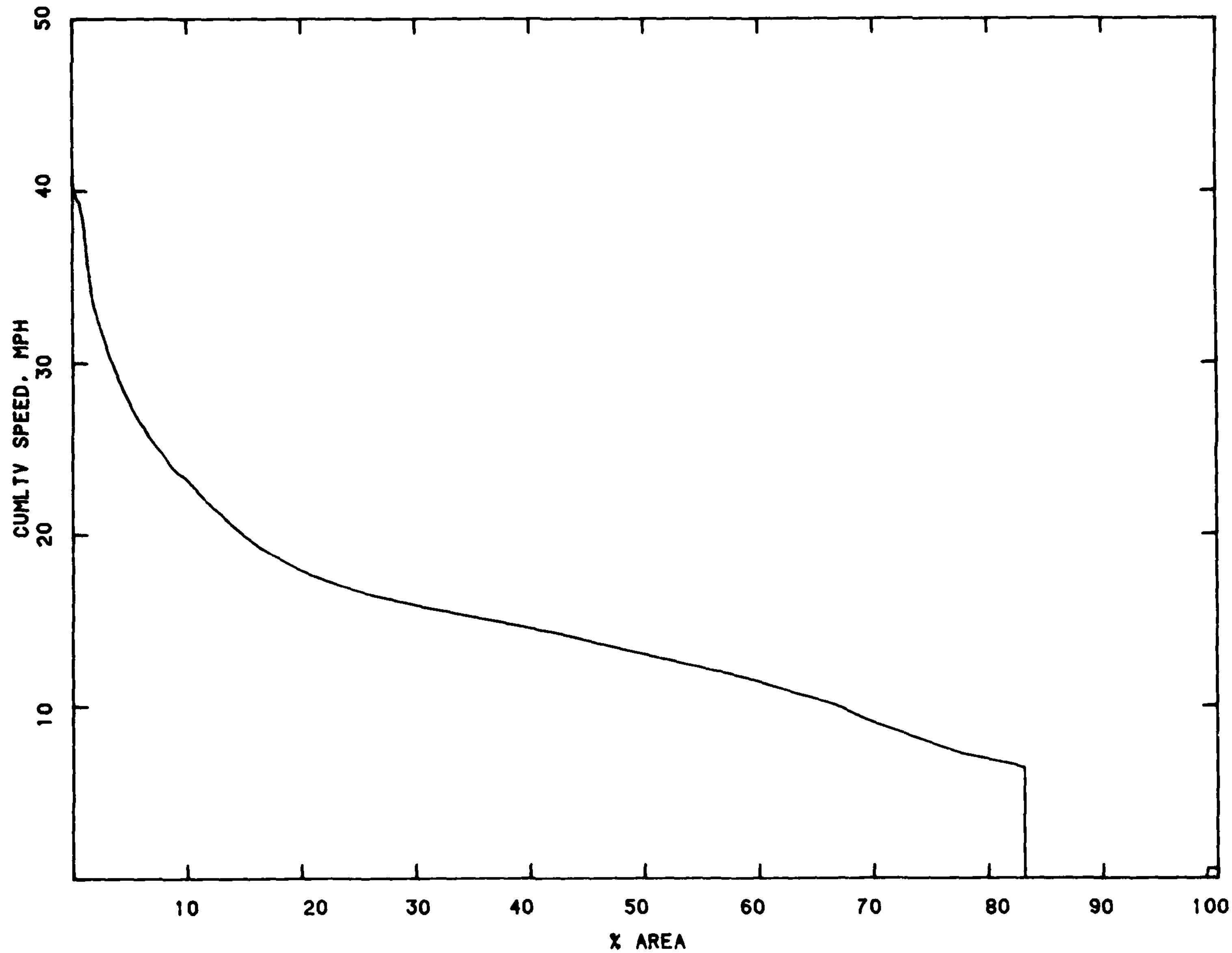

PERFORMANCE OF HMMWVG IN EUROPE1 SNOW
ACTUAL SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF HMMWVG IN JORDAN DRY
CUMLTV SPEED, MPH
% AREA
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100

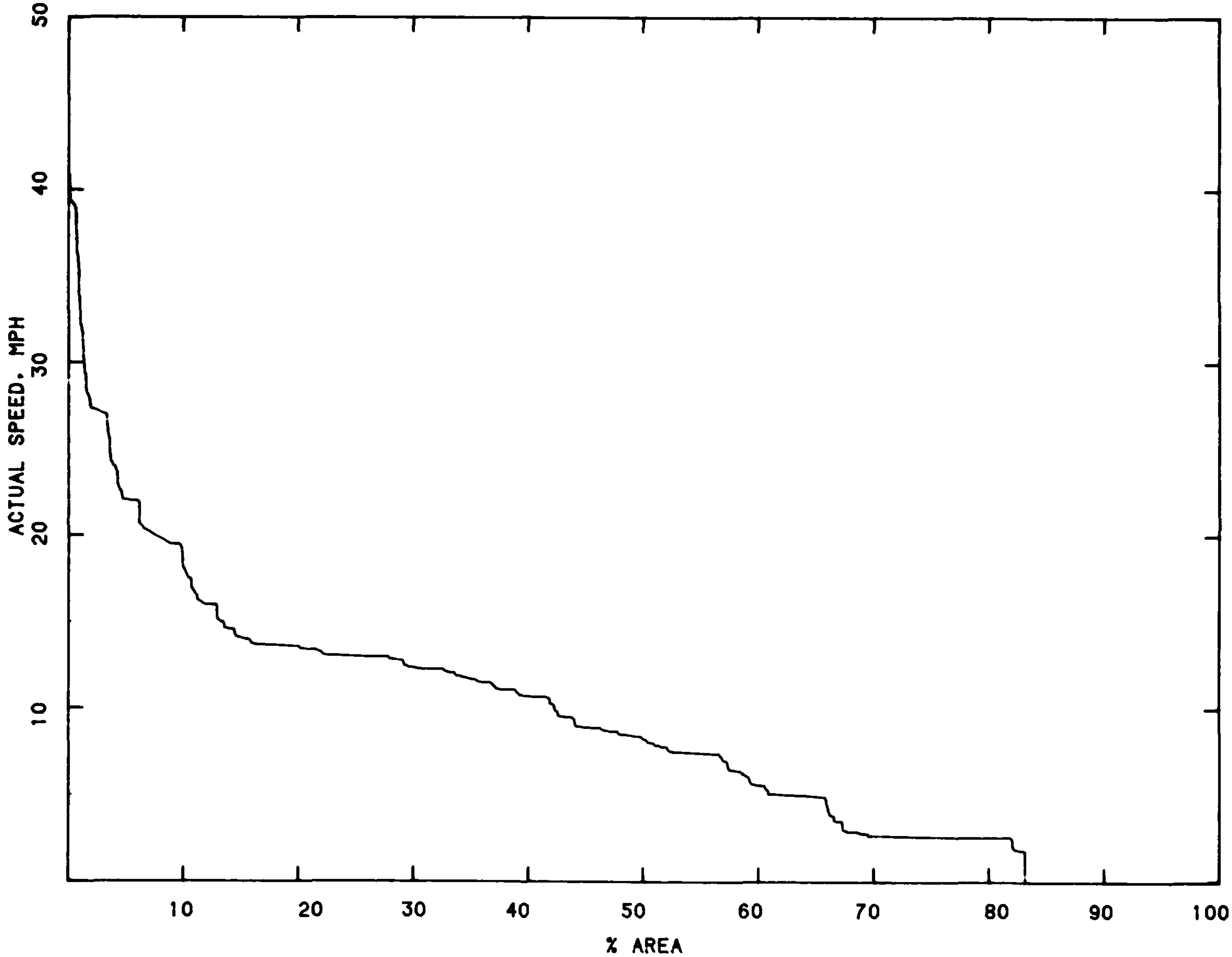
PERFORMANCE OF HMMWVG IN JORDAN DRY

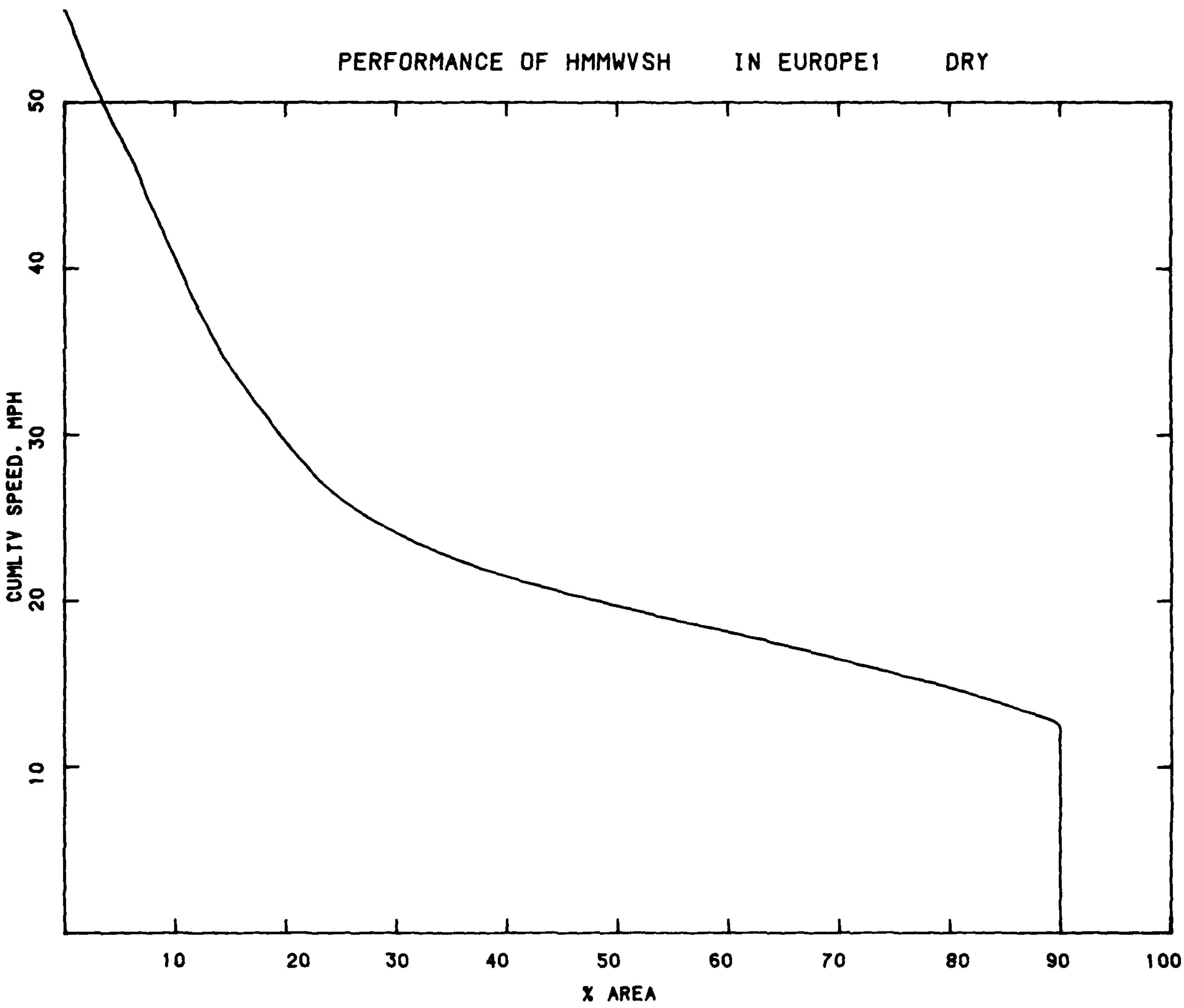


PERFORMANCE OF HMMWVG IN JORDAN WET

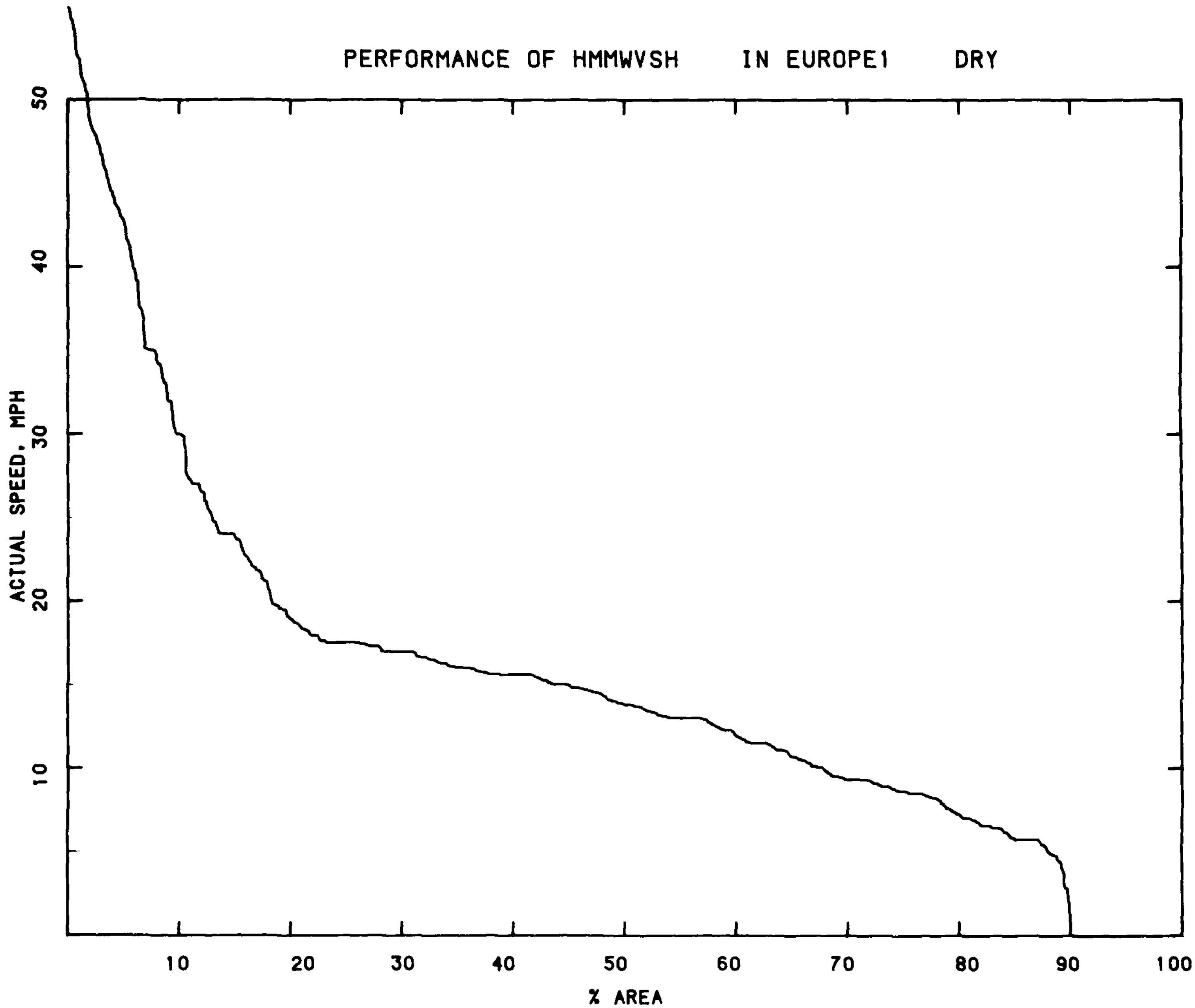


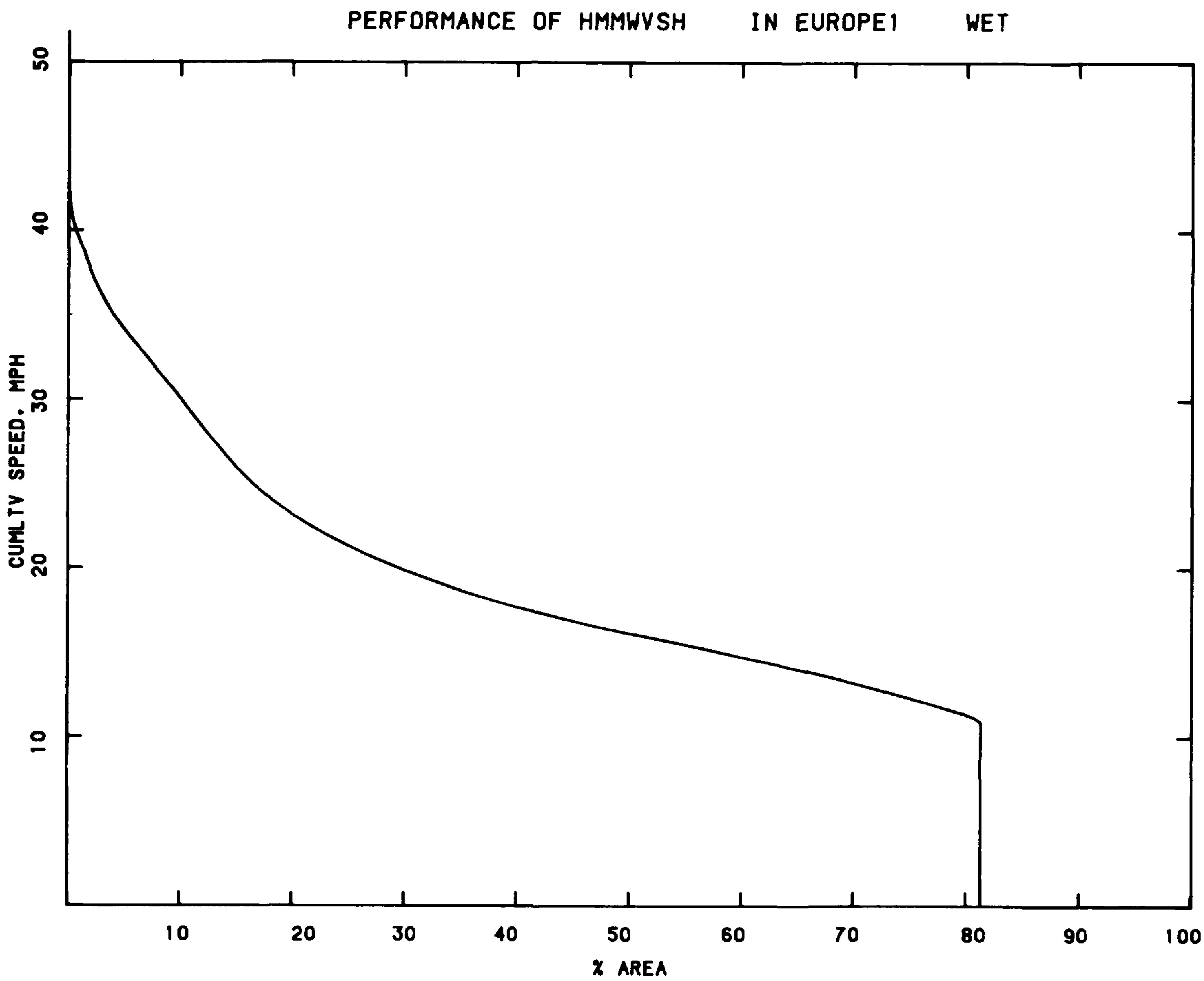
PERFORMANCE OF HMMWVG IN JORDAN WET

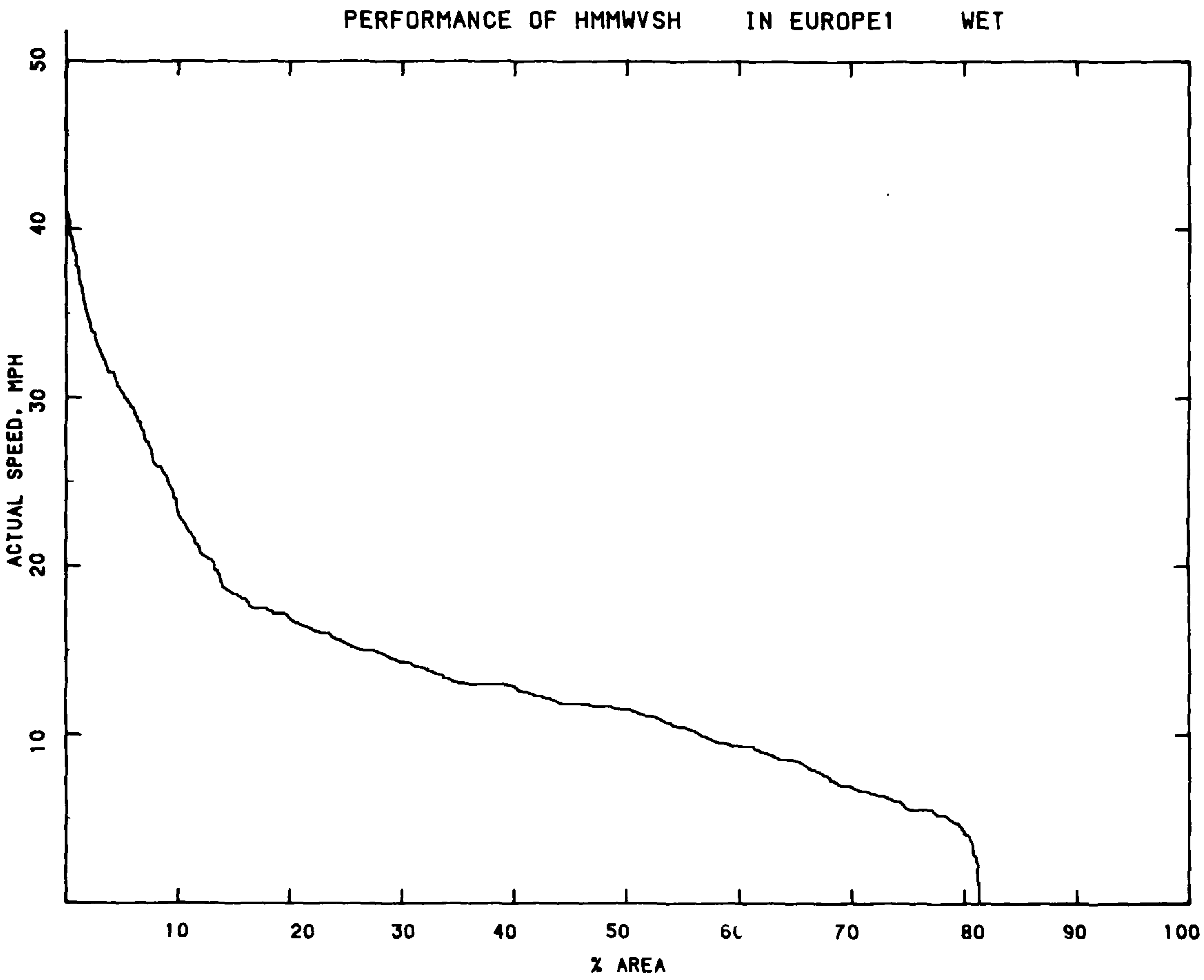


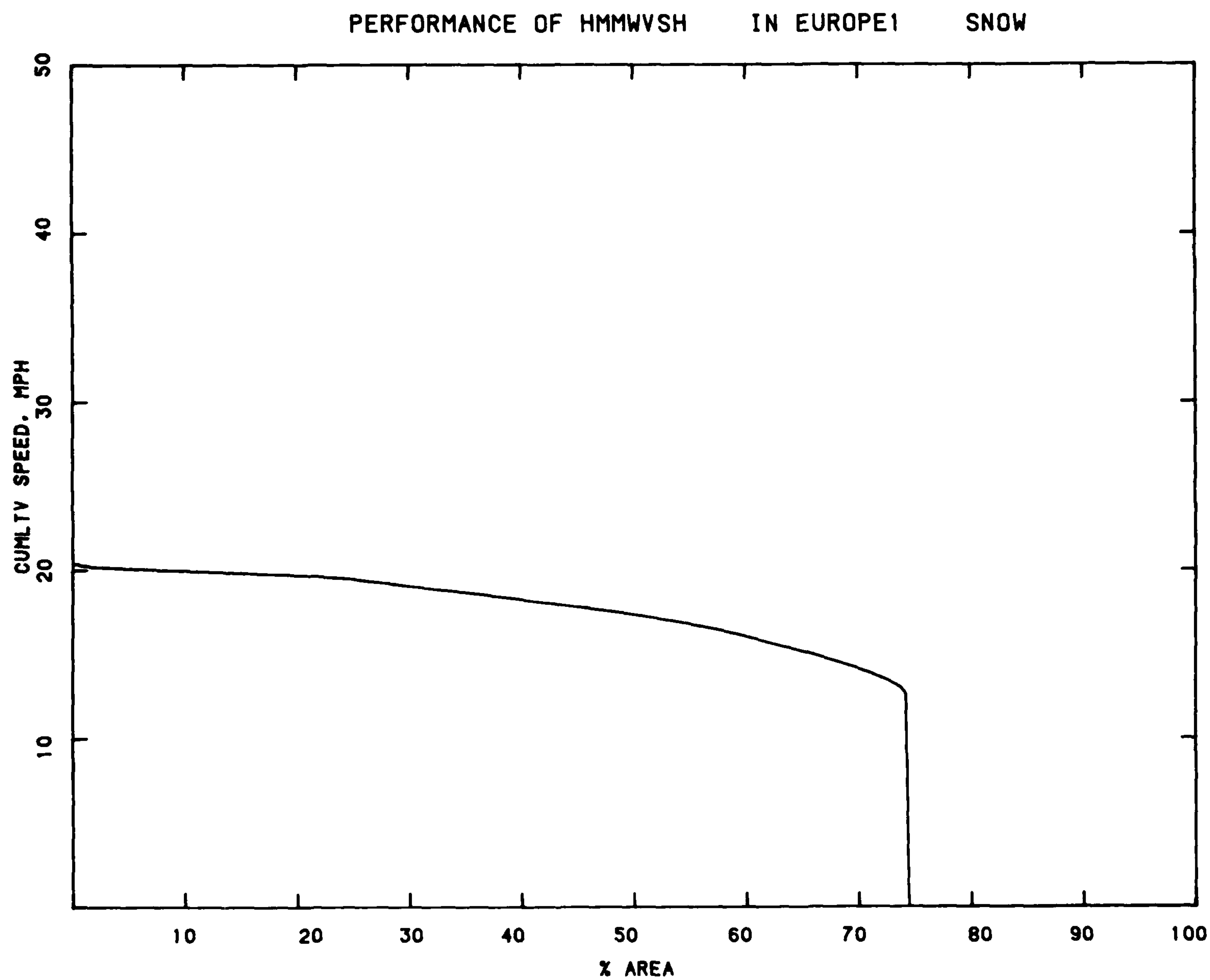

PERFORMANCE OF HMMWVSH IN EUROPE1 DRY
CUMLTV SPEED, MPH
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
% AREA

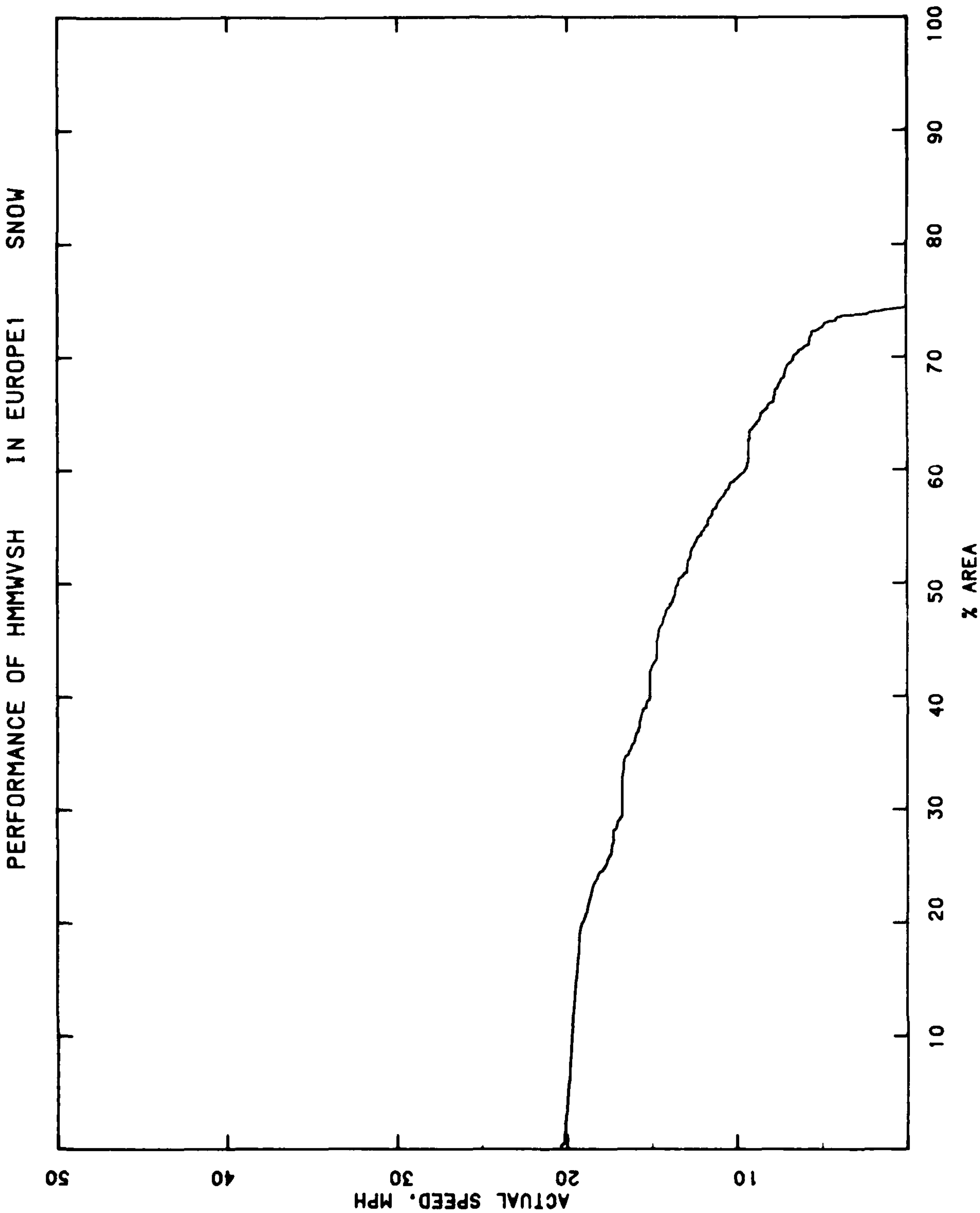
PERFORMANCE OF HMMWVSH IN EUROPE1 DRY

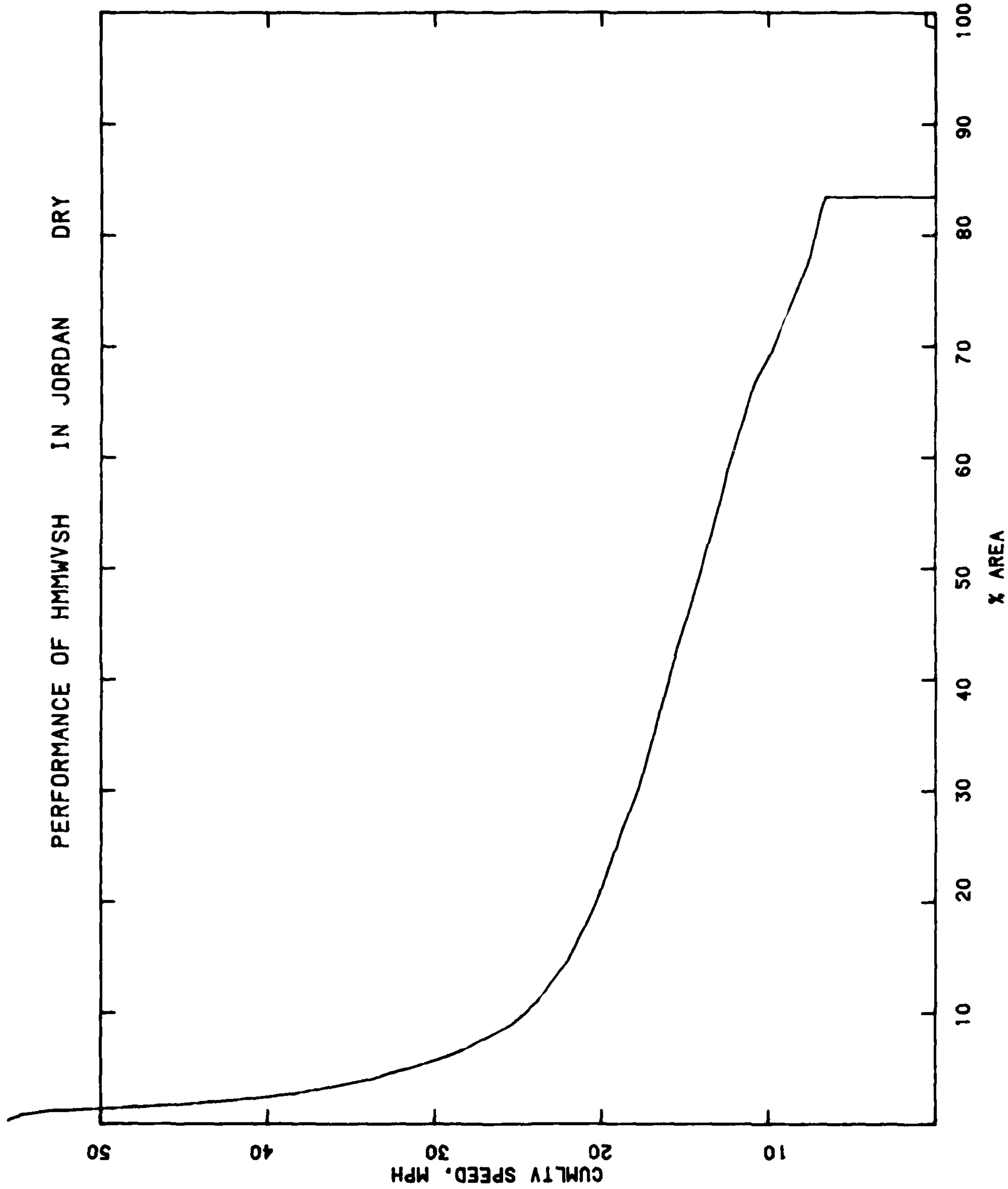


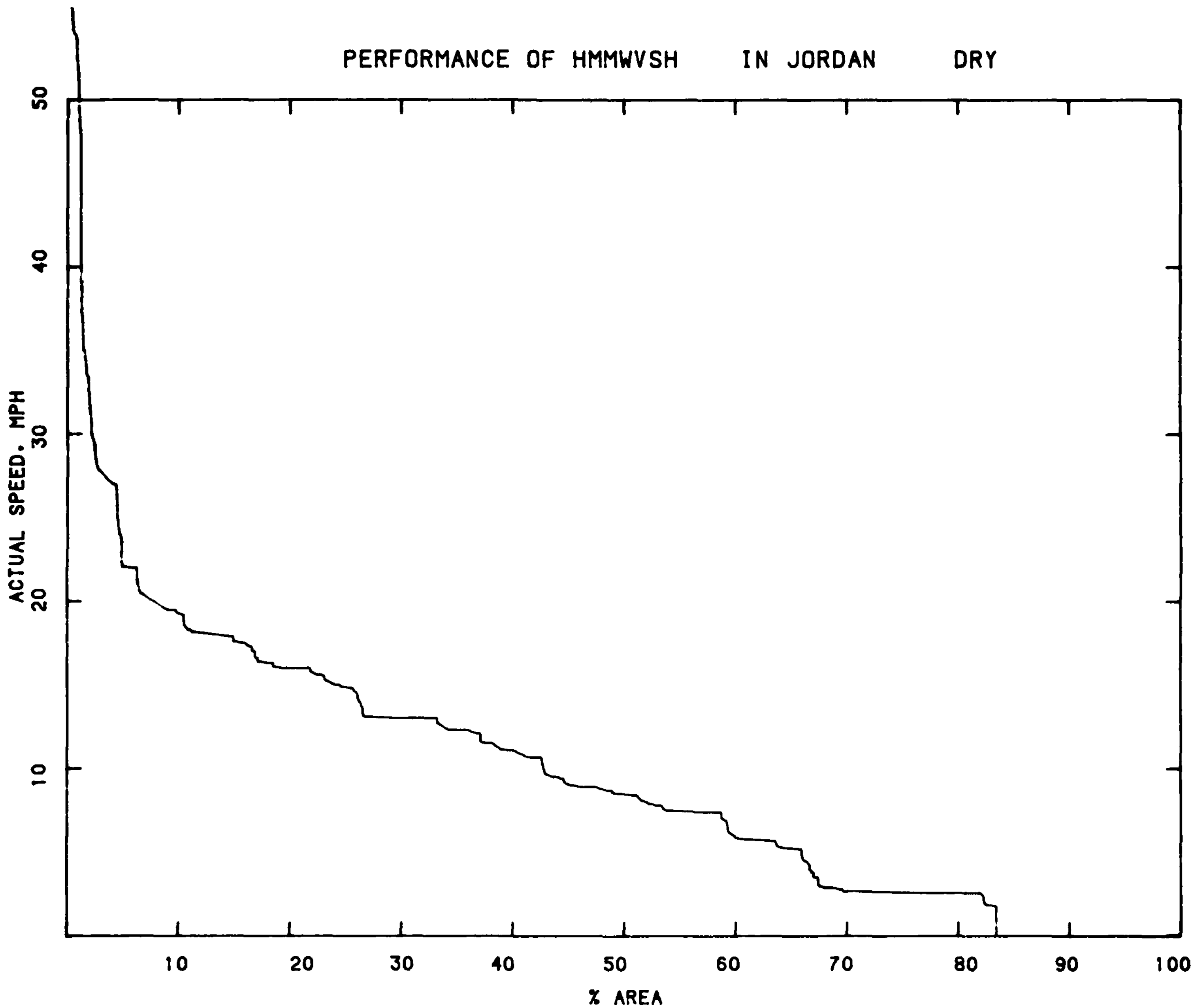

PERFORMANCE OF HMMWVSH IN EUROPE1 WET
CUMLTV SPEED, MPH
10
20
30
40
50
% AREA
60
70
80
90
100


PERFORMANCE OF HMMWVSH IN EUROPE1 WET
ACTUAL SPEED, MPH
50
40
30
20
10
10
20
30
40
50
6C
70
80
90
100
% AREA

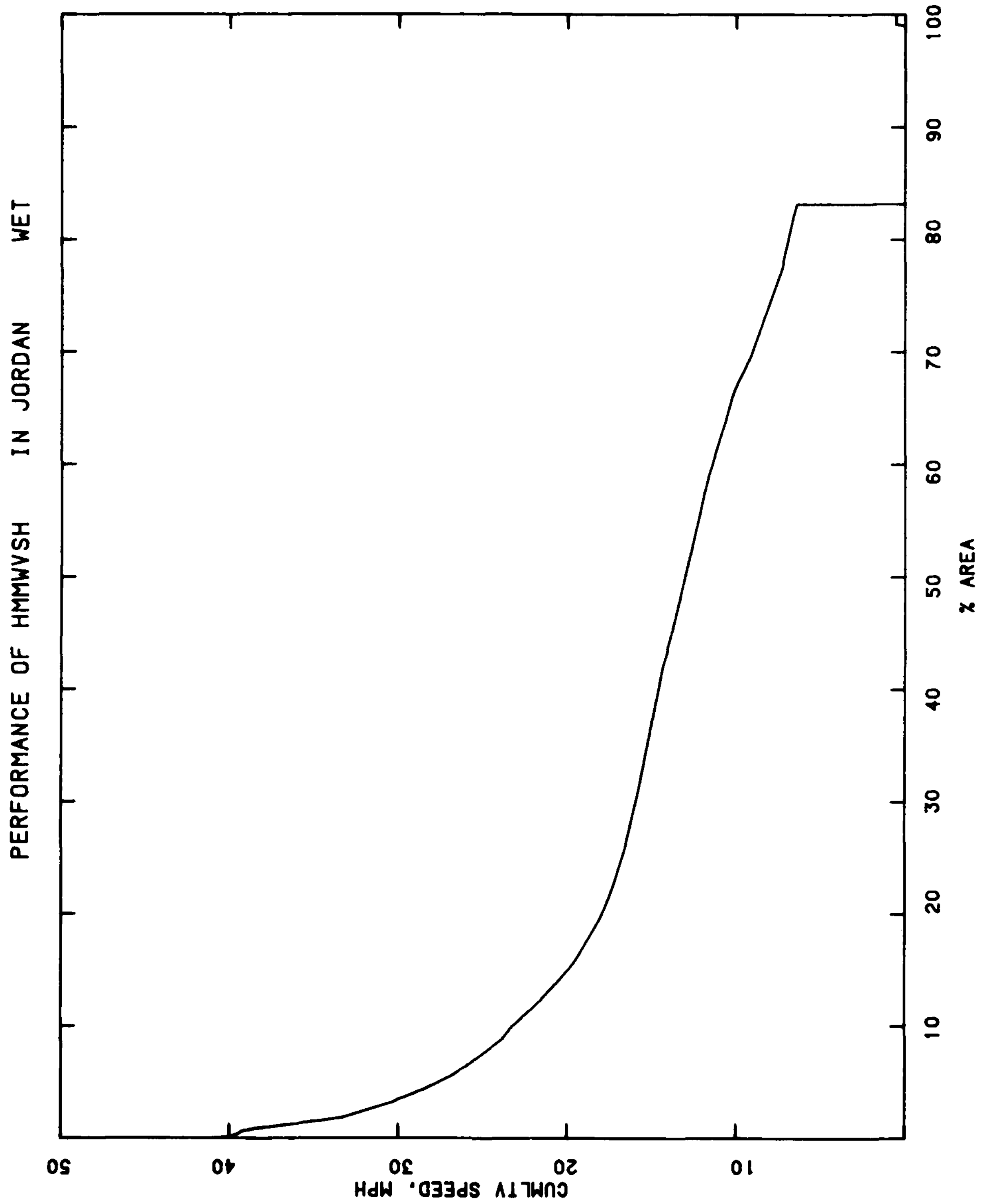

PERFORMANCE OF HMMWVSH IN EUROPE1 SNOW
CUMLTV SPEED, MPH
10
20
30
40
50
% AREA
10
20
30
40
50
60
70
80
90
100


PERFORMANCE OF HMMWVSH IN EUROPE1 SNOW
% AREA
10
20
30
40
50
60
70
80
90
100
ACTUAL SPEED, MPH
10
20
30
40
50

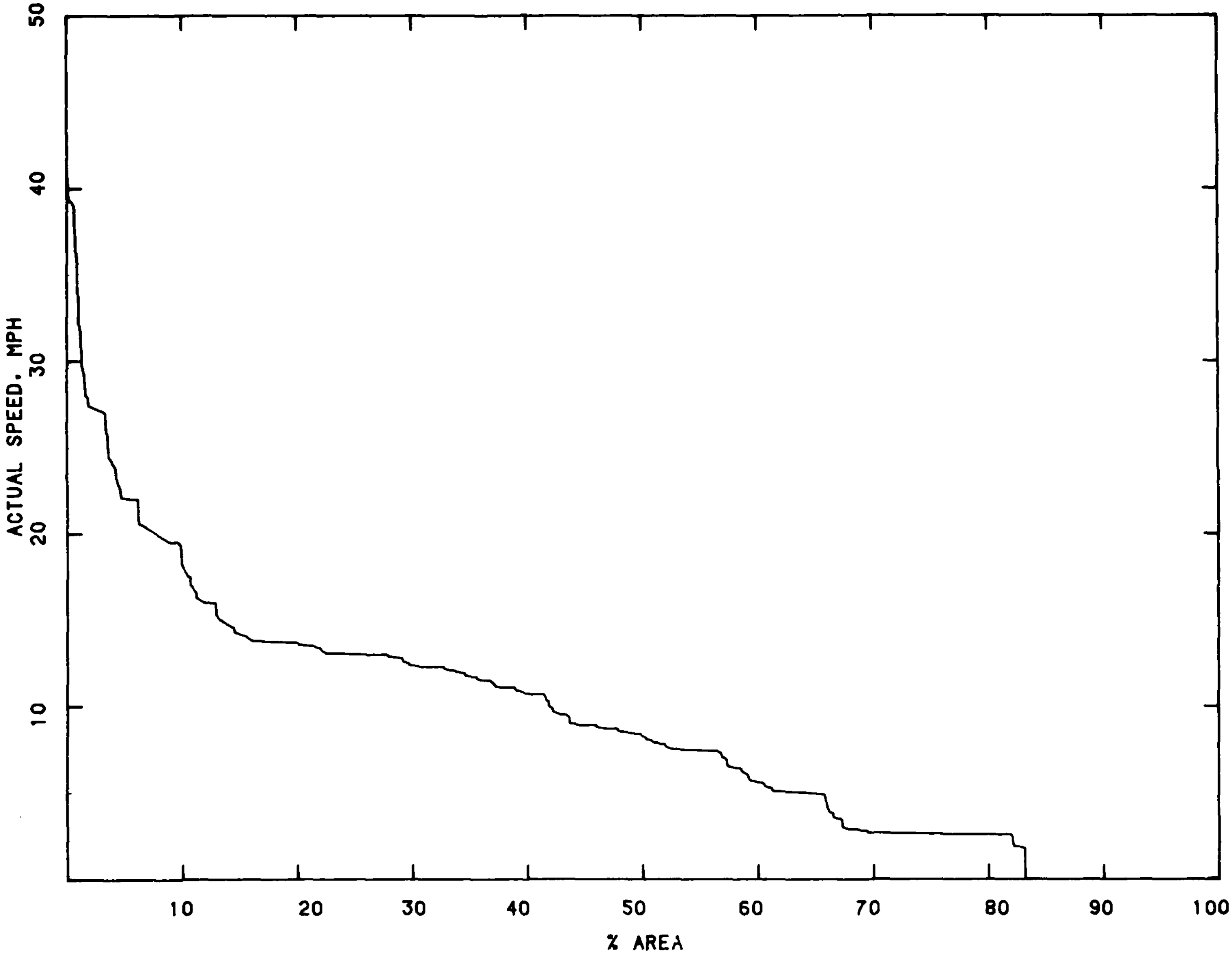

PERFORMANCE OF HMMWVSH IN JORDAN DRY
CUMLTV SPEED, MPH
% AREA
10
20
30
40
50
60
70
80
90
100



PERFORMANCE OF HMMWVSH IN JORDAN DRY
ACTUAL SPEED, MPH
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
% AREA


PERFORMANCE OF HMMWVSH IN JORDAN WET
CUMLTV SPEED, MPH
% AREA
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100

PERFORMANCE OF HMMWVSH IN JORDAN WET



PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY - DRY			JORDAN - DRY		
	V_{50} MPH	V_{90} MPH	PERCENT* NOGO	V_{50} MPH	V_{90} MPH	PERCENT* NOGO
HMMWV W/M101	18.6	NO-GO	12.3	13.7	NO-GO	17.4
M151 W/M416	16.4	NO-GO	15.4	10.7	NO-GO	13.2
M561 W/M101	15.1	NO-GO	11.5	12.5	NO-GO	16.4
M151 W/AMMO TRL	16.5	NO-GO	14.8	10.7	NO-GO	13.1
M151A2	17.9	NO-GO	11.7	10.8	NO-GO	13.1
M561	15.8	NO-GO	10.2	12.5	NO-GO	16.4
HMMWVG	20.3	NO-GO	10.0	14.0	NO-GO	16.5
HMMWV W/SHELTER	19.7	NO-GO	10.0	13.9	NO-GO	16.5

*DENOTES PERCENT OF AREA

AREAL OCCURRENCE OF VEHICLE NOGOS

GERMANY - DRY

VEHICLE	FACTORS CAUSING VEHICLE NOGOS			
	SURFACE STRENGTH LESS THAN VCI_1	AVAIL TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE INTERFERENCE	AVAIL TRACTION LESS THAN TOTAL RESISTING FORCES
HMMWV W/M101	0.1	4.5	7.3	0.4
M151 W/M416	0.0	4.9	8.8	1.7
M561 W/M101	0.0	3.6	7.4	0.5
M151 W/ AMMO TRL	0.0	5.5	8.6	0.7
M151A2	0.0	2.5	8.7	0.5
M561	0.0	2.5	7.3	0.4
HMMWVG	0.0	2.5	7.1	0.4
HMMWV W/SHELTER	0.0	2.5	7.1	0.4

AREAL OCCURRENCE OF FACTORS LIMITING
VEHICLE SPEEDS

GERMANY - DRY

VEHICLE	FACTORS LIMITING VEHICLE SPEEDS						
	RIDE	SOIL & SLOPE RESIST	VISIBILITY IN VEGETATION	MANEUVERING IN VEGETATION	ALL RESIST FORCES	ACCEL & DECEL BETWEEN OBSTACLES	OBSTACLE INTERFERENCE
HMMWV W/M101	15.7	3.4	22.2	22.1	4.1	20.3	-
M151 W/M416	18.4	6.2	21.5	9.4	1.8	27.3	-
M561 W/M101	26.1	6.5	10.5	21.3	4.3	19.9	-
M151 W/AMMO TRL	18.7	5.6	22.0	9.3	2.1	27.5	-
M151A2	21.4	4.9	22.2	9.7	1.4	28.7	-
M561	31.0	5.7	7.7	20.6	3.9	20.9	-
HMMWVG	18.0	3.5	22.0	21.9	2.7	21.9	-
HMMWV W/SHELTER	17.6	3.5	22.1	22.1	3.1	21.7	-

AREAL OCCURRENCE OF VEHICLE NOGOS

JORDAN - DRY

VEHICLE	FACTORS CAUSING VEHICLE NOGOS			
	SURFACE STRENGTH LESS THAN VCI_1	AVAIL TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE INTERFERENCE	AVAIL TRACTION LESS THAN TOTAL RESISTING FORCES
HMMWV W/M101	0.0	0.0	17.4	0.0
M151 W/M416	0.0	0.0	13.2	0.0
M561 W/M101	0.0	0.0	16.4	0.0
M151 W/ AMMO TRL	0.0	0.0	13.1	0.0
M151A2	0.0	0.0	13.1	0.0
M561	0.0	0.0	16.4	0.0
HMMWVG	0.0	0.0	16.5	0.0
HMMWV W/SHELTER	0.0	0.0	16.5	0.0

AREAL OCCURRENCE OF FACTORS LIMITING
VEHICLE SPEEDS

JORDAN - DRY

VEHICLE	FACTORS LIMITING VEHICLE SPEEDS						
	RIDE	SOIL & SLOPE RESIST	VISIBILITY IN VEGETATION	MANEUVERING IN VEGETATION	ALL RESIST FORCES	ACCEL & DECEL BETWEEN OBSTACLES	OBSTACLE INTERFERENCE
HMMWV W/M101	36.0	0.8	11.3	7.8	0.0	26.6	—
M151 W/M416	42.3	1.1	8.9	8.6	0.0	26.0	—
M561 W/M101	44.9	1.4	2.0	8.6	0.1	26.7	—
M151 W/AMMO TRL	42.3	1.2	8.9	8.4	0.0	26.2	—
M151A2	42.7	1.0	8.6	8.6	0.0	26.1	—
M561	46.5	1.1	0.7	8.6	0.0	26.7	—
HMMWVG	36.9	0.7	10.5	7.9	0.0	27.6	—
HMMWV W/SHELTER	36.2	0.8	11.2	7.9	0.0	27.6	—

PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY - WET			JORDAN - WET		
	V_{50} MPH	V_{90} MPH	PERCENT* NOGO	V_{50} MPH	V_{90} MPH	PERCENT* NOGO
HMMWV W/M101	14.2	NO-GO	28.6	12.5	NO-GO	19.0
M151 W/M416	11.5	NO-GO	30.1	9.7	NO-GO	15.5
M561 W/M101	12.3	NO-GO	25.5	11.9	NO-GO	18.1
M151 W/AMMO TRL	11.6	NO-GO	32.3	9.6	NO-GO	19.0
M151A2	14.5	NO-GO	19.8	10.1	NO-GO	14.0
M561	13.8	NO-GO	18.4	12.2	NO-GO	16.8
HMMWVG	16.3	NO-GO	18.6	13.0	NO-GO	16.8
HMMWV W/SHELTER	16.1	NO-GO	18.3	13.0	NO-GO	16.8

*DENOTES PERCENT OF AREA

AREAL OCCURRENCE OF VEHICLE NOGOS

GERMANY - WET

VEHICLE	FACTORS CAUSING VEHICLE NOGOS			
	SURFACE STRENGTH LESS THAN VCI_1	AVAIL TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE INTERFERENCE	AVAIL TRACTION LESS THAN TOTAL RESISTING FORCES
HMMWV W/M101	0.5	19.3	7.0	1.8
M151 W/M416	0.2	19.0	8.6	2.3
M561 W/M101	0.4	17.2	6.8	1.1
M151 W/ AMMO TRL	0.1	21.8	8.6	1.8
M151A2	0.1	9.7	8.7	1.3
M561	0.2	10.3	6.8	1.1
HMMWVG	0.4	10.[illegible]	6.9	1.2
HMMWV W/SHELTER	0.4	10.2	6.9	0.8

AREAL OCCURRENCE OF FACTORS LIMITING
VEHICLE SPEEDS

GERMANY - WET

VEHICLE	FACTORS LIMITING VEHICLE SPEEDS						
	RIDE	SOIL & SLOPE RESIST	VISIBILITY IN VEGETATION	MANEUVERING IN VEGETATION	ALL RESIST FORCES	ACCEL & DECEL BETWEEN OBSTACLES	OBSTACLE INTERFERENCE
HMMWV W/M101	8.4	1.5	25.3	17.9	5.4	13.0	-
M151 W/M416	9.9	3.1	22.6	6.6	5.2	22.5	-
M561 W/M101	13.7	5.8	15.3	18.1	7.4	14.3	-
M151 W/AMMO TRL	9.9	2.4	23.4	6.5	3.4	22.1	-
M151A2	15.8	1.3	26.9	8.4	2.3	25.5	-
M561	18.8	4.0	15.7	20.1	5.9	17.2	-
HMMWVG	12.7	1.2	25.1	20.8	3.6	17.9	-
HMMWV W/SHELTER	12.5	1.6	24.2	20.7	4.9	17.8	-

AREAL OCCURRENCE OF VEHICLE NOGOS

JORDAN - WET

VEHICLE	FACTORS CAUSING VEHICLE NOGOS			
	SURFACE STRENGTH LESS THAN VCI_1	AVAIL TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE INTERFERENCE	AVAIL TRACTION LESS THAN TOTAL RESISTING FORCES
HMMWV W/M101	0.0	1.2	17.4	0.4
M151 W/M416	0.0	1.2	13.9	0.4
M561 W/M101	0.0	1.1	16.4	0.6
M151 W/ AMMO TRL	0.0	1.5	13.9	3.6
M151A2	0.0	0.0	13.9	0.1
M561	0.0	0.0	16.4	0.4
HMMWVG	0.0	0.0	16.5	0.3
HMMWV W/SHELTER	0.0	0.0	16.5	0.3

AREAL OCCURRENCE OF FACTORS LIMITING VEHICLE SPEEDS

JORDAN - WET

VEHICLE	FACTORS LIMITING VEHICLE SPEEDS						
	RIDE	SOIL & SLOPE RESIST	VISIBILITY IN VEGETATION	MANEUVERING IN VEGETATION	ALL RESIST FORCES	ACCEL & DECEL BETWEEN OBSTACLES	OBSTACLE INTERFERENCE
HMMWV W/M101	30.8	0.0	17.6	7.3	0.1	25.2	-
M151 W/M416	36.6	0.3	13.4	8.5	0.6	25.1	-
M561 W/M101	35.2	1.0	11.6	8.1	0.1	26.0	-
M151 W/AMMO TRL	34.9	0.5	13.5	8.3	0.2	23.7	-
M151A2	38.3	0.1	12.9	8.5	0.2	26.0	-
M561	38.2	0.8	9.2	8.6	0.2	26.4	-
HMMWVG	33.7	0.0	15.2	7.7	0.2	26.5	-
HMMWV W/SHELTER	33.9	0.1	14.9	7.7	0.2	26.5	-

PREDICTED VEHICLE MOBILITY

CUMULATIVE AVERAGE SPEEDS

VEHICLE	GERMANY - SNOW					
	V_{50} MPH	V_{90} MPH	PERCENT* NOGO	V_{50} MPH	V_{90} MPH	PERCENT* NOGO
HMMWV W/M101	NO-GO	NO-GO	50.3			
M151 W/M416	NO-GO	NO-GO	54.9			
M561 W/M101	7.8	NO-GO	38.7			
M151 W/AMMO TRL	NO-GO	NO-GO	63.0			
M151A2	16.8	NO-GO	26.7			
M561	11.5	NO-GO	25.0			
HMMWVG	18.6	NO-GO	25.2			
HMMWV W/SHELTER	17.3	NO-GO	25.4			

*DENOTES PERCENT OF AREA

AREAL OCCURRENCE OF VEHICLE NOGOS

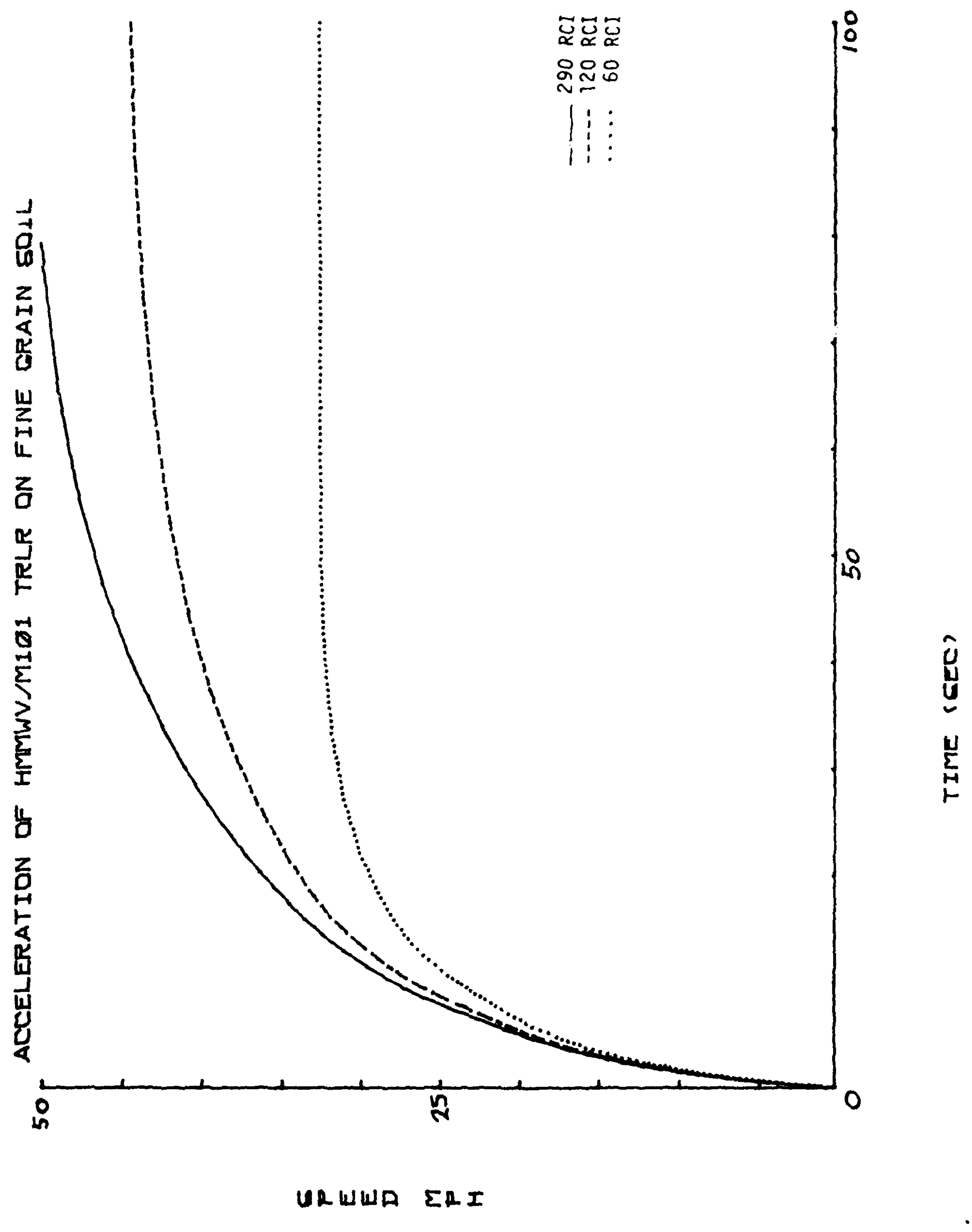
GERMANY - SNOW

VEHICLE	FACTORS CAUSING VEHICLE NOGOS			
	SURFACE STRENGTH LESS THAN VCI_1	AVAIL TRACTION LESS THAN SOIL & SLOPE RESISTANCE	OBSTACLE INTERFERENCE	AVAIL TRACTION LESS THAN TOTAL RESISTING FORCES
HMMWV W/M101	0.0	40.6	7.1	2.6
M151 W/M416	0.0	44.6	8.6	1.7
M561 W/M101	0.0	29.4	6.8	2.5
M151 W/ AMMO TRL	0.0	53.5	7.5	2.0
M151A2	0.0	13.5	8.6	4.6
M561	0.0	13.7	6.8	4.5
HMMWVG	0.0	13.7	7.0	4.5
HMMWV W/SHELTER	0.0	17.8	7.0	4.6

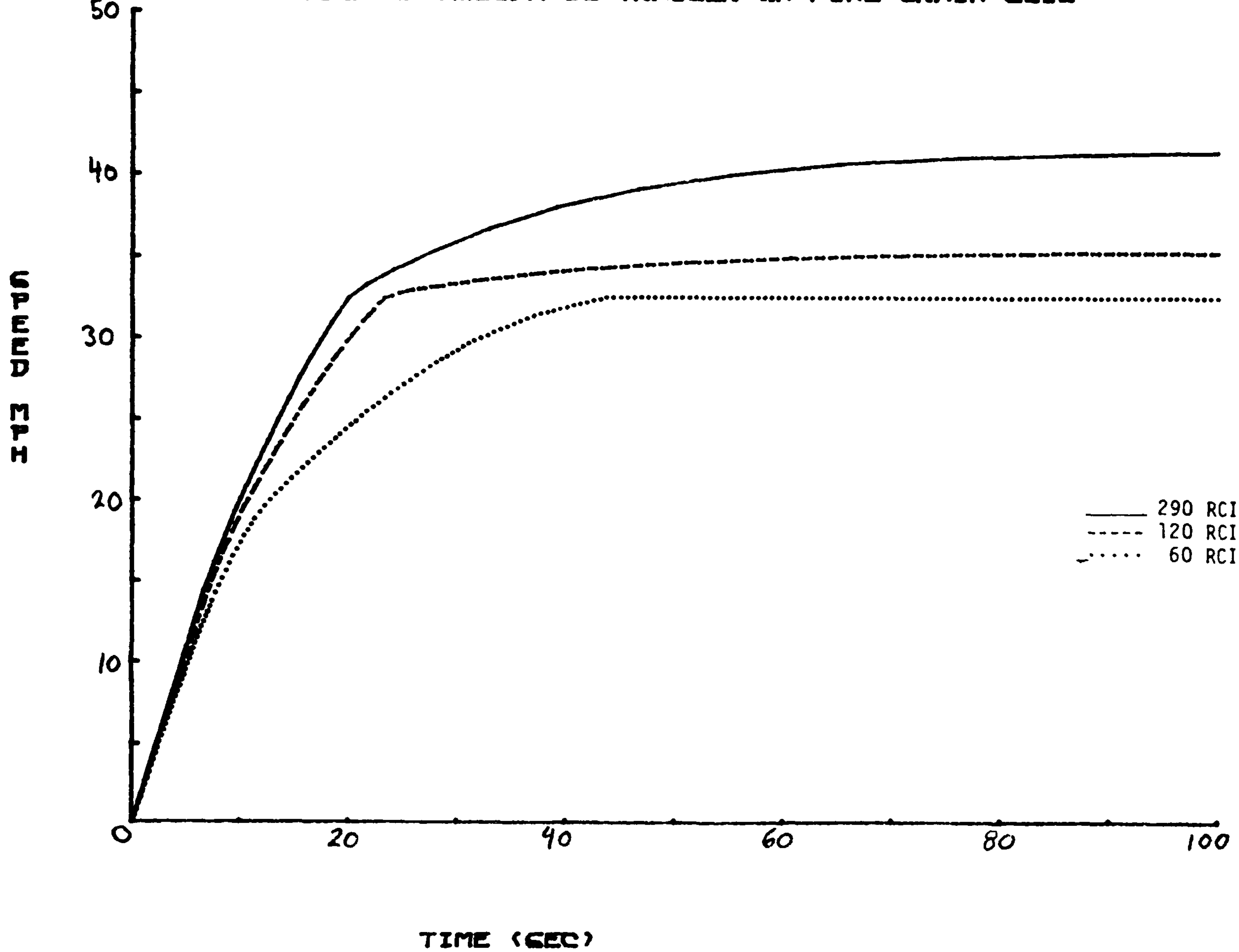
AREAL OCCURRENCE OF FACTORS LIMITING
VEHICLE SPEEDS

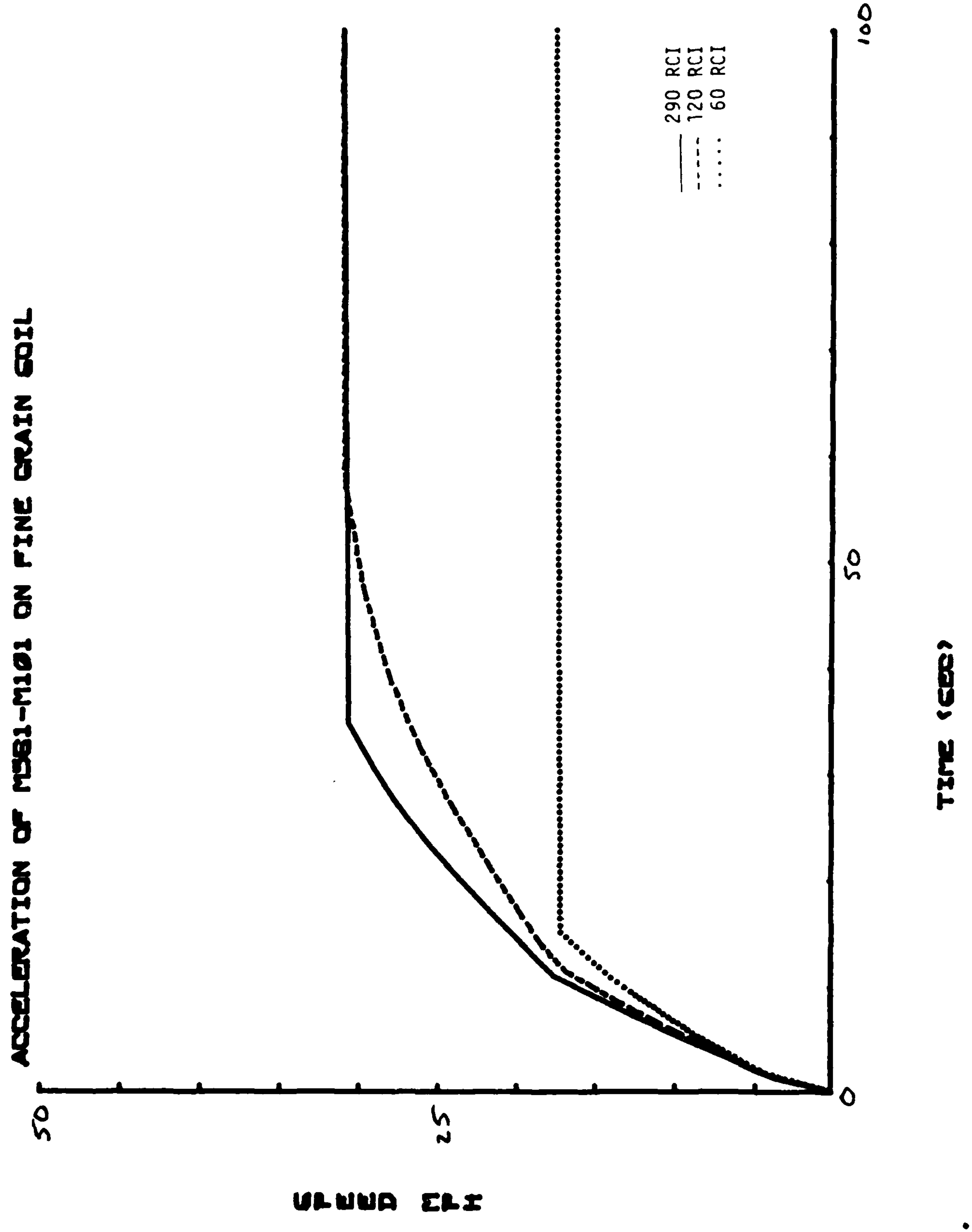
GERMANY - SNOW

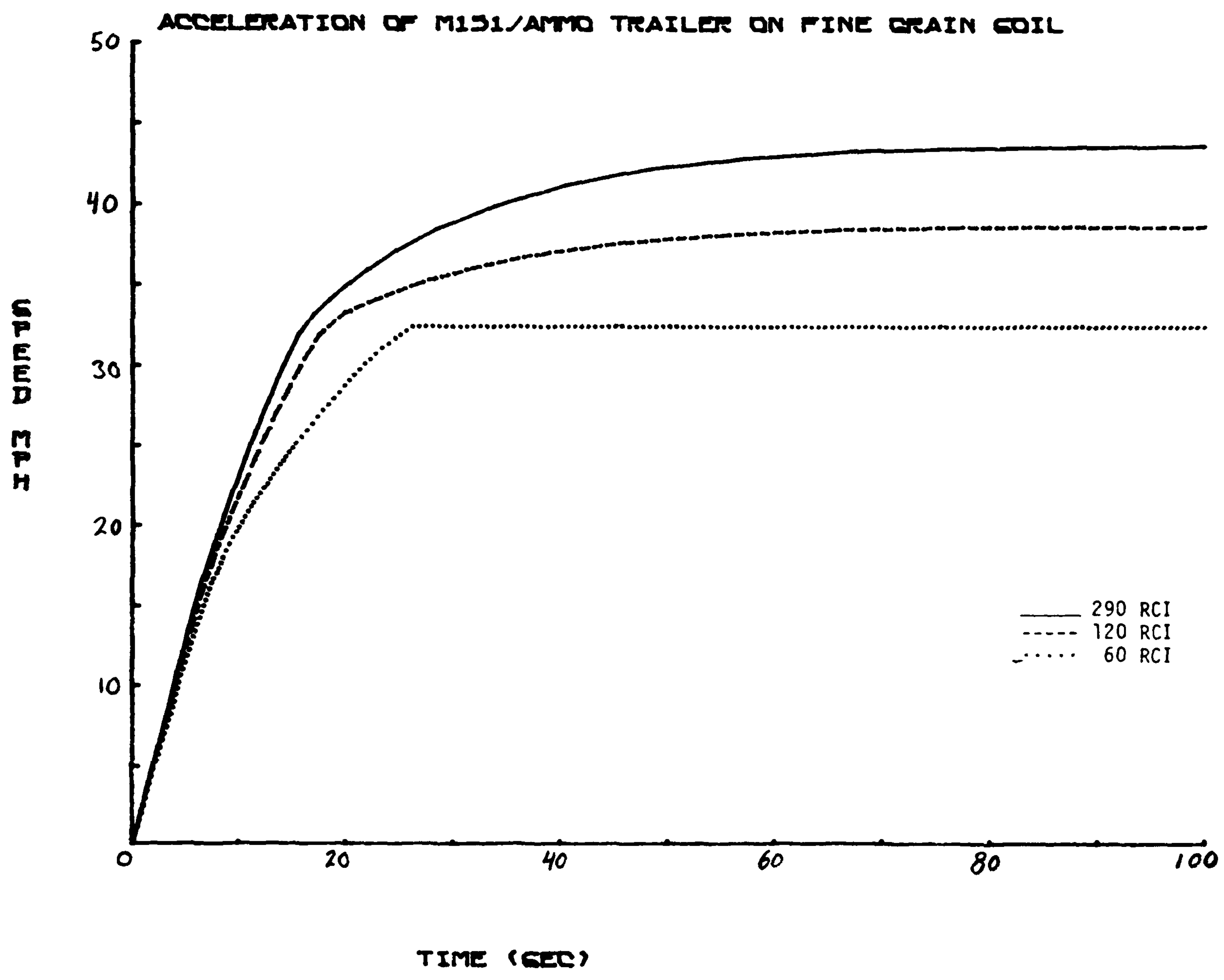
VEHICLE	FACTORS LIMITING VEHICLE SPEEDS						
	RIDE	SOIL & SLOPE RESIST	VISIBILITY IN VEGETATION	MANEUVERING IN VEGETATION	ALL RESIST FORCES	ACCEL & DECEL BETWEEN OBSTACLES	OBSTACLE INTERFERENCE
HMMWV W/M101	0.2	5.3	7.7	9.9	19.9	6.9	-
M151 W/M416	0.3	5.6	5.5	3.7	17.1	12.8	-
M561 W/M101	0.7	20.5	1.9	12.4	21.0	4.8	-
M151 W/AMMO TRL	0.4	5.3	4.1	3.1	12.0	12.0	-
M151A2	3.9	9.5	11.4	7.1	20.0	21.6	-
M561	4.1	14.0	2.9	14.7	27.3	12.0	-
HMMWVG	1.3	6.3	12.6	15.8	23.5	15.4	-
HMMWV W/SHELTER	0.8	6.3	10.0	15.3	27.4	14.8	-

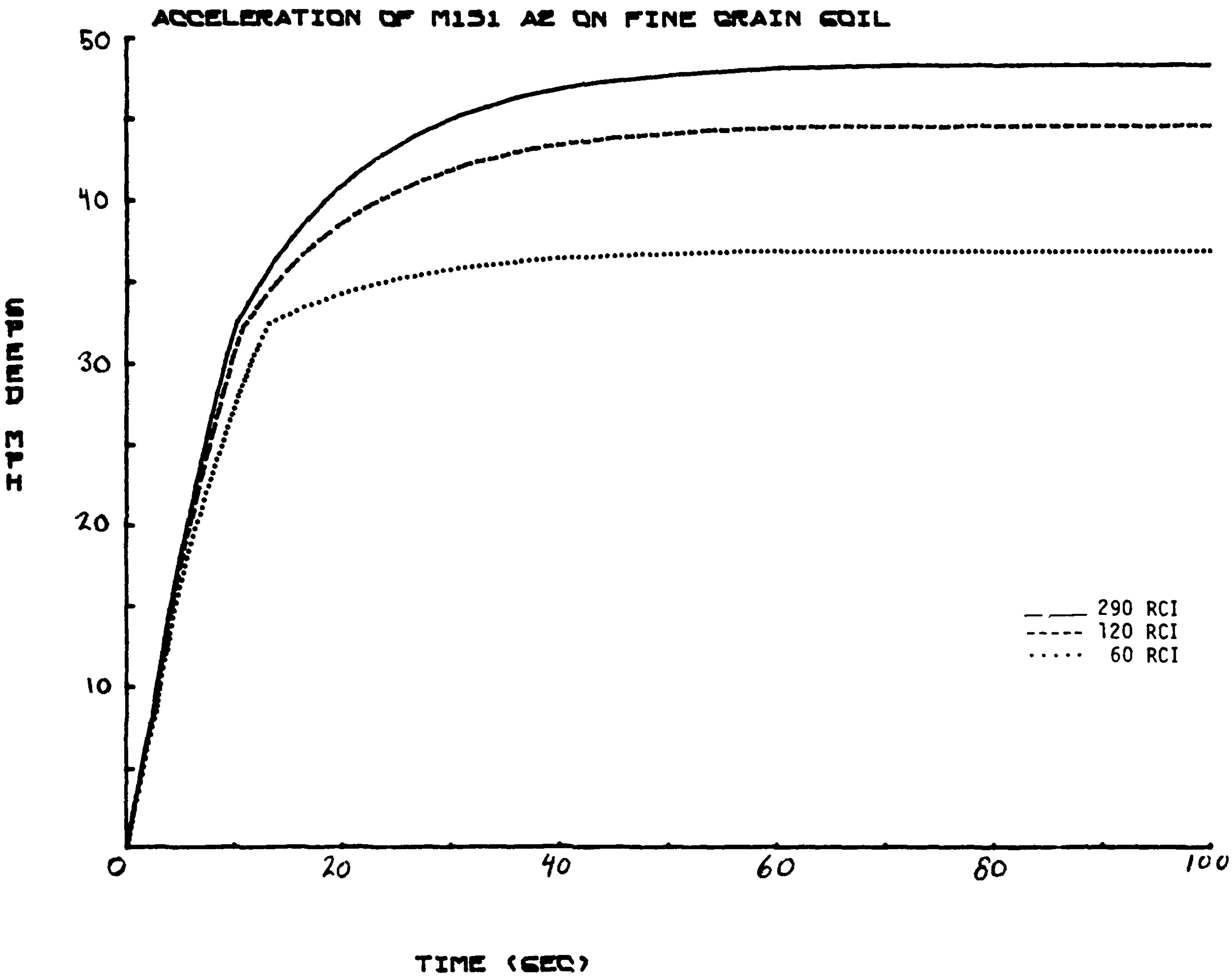

ACCELERATION OF HMMWV/M101 TRLR ON FINE GRAIN SOIL
290 RCI
120 RCI
60 RCI
50
25
0
50
100
TIME (SEC)

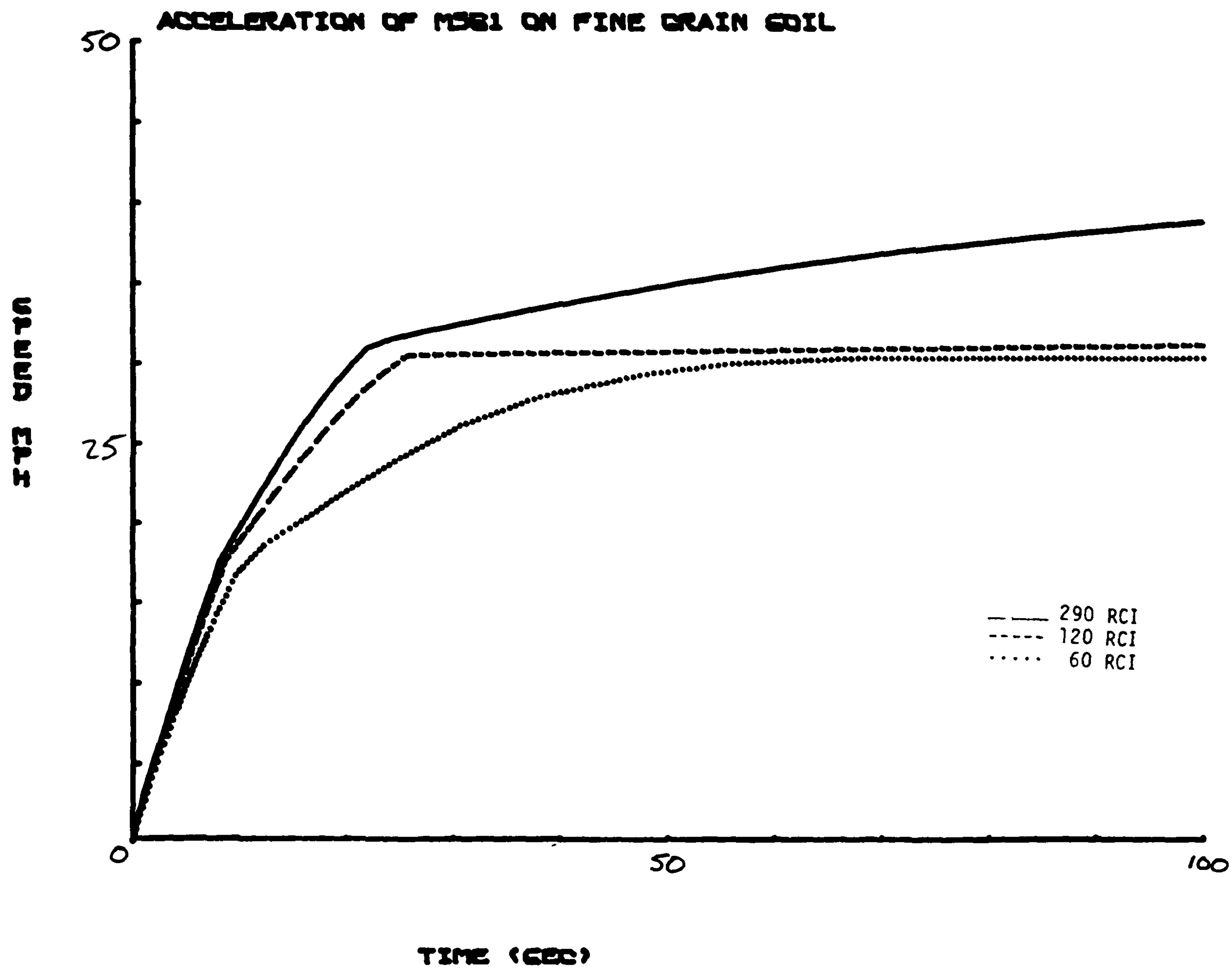
ACCELERATION OF M151/M418 TRAILER ON FINE GRAIN SOIL

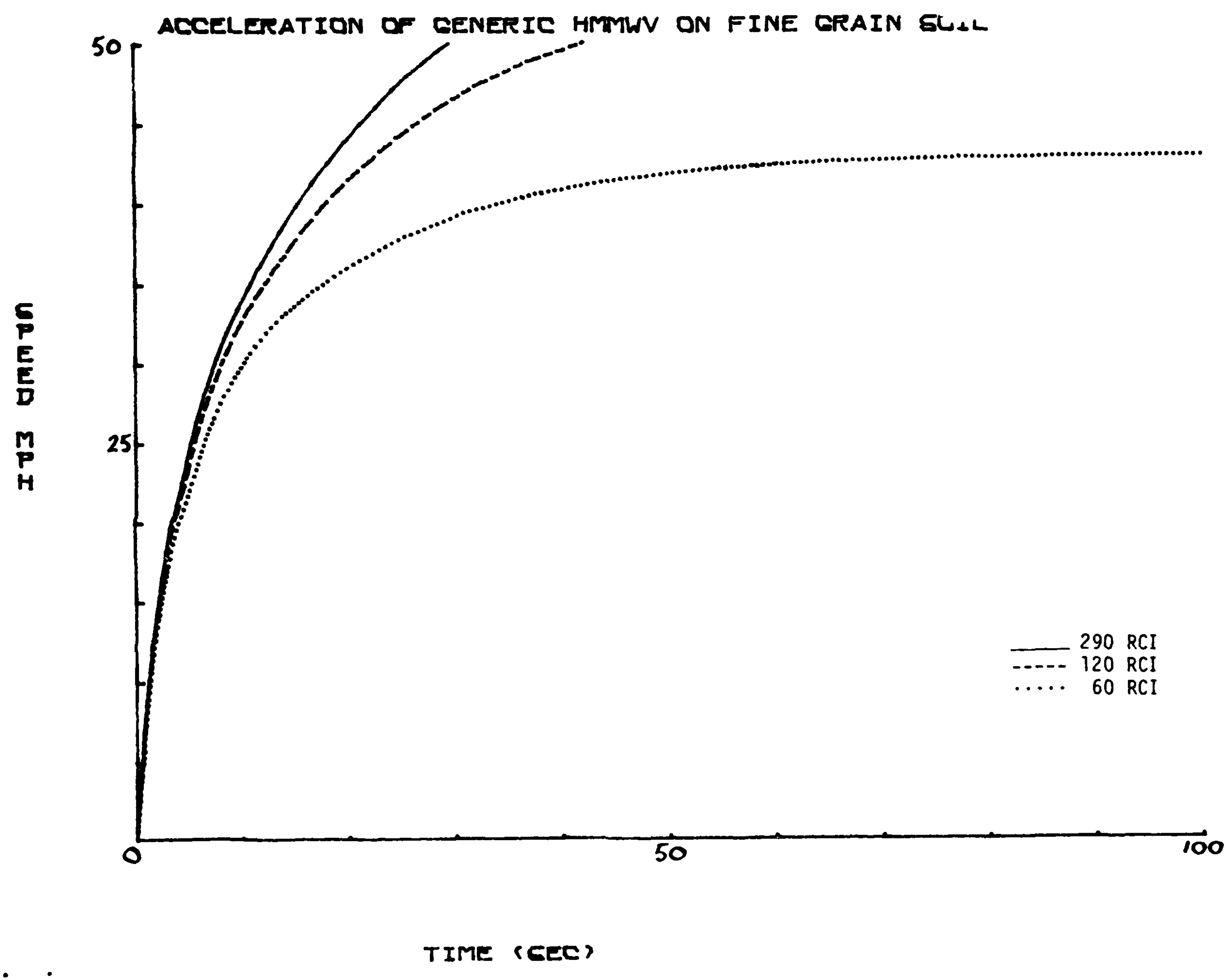


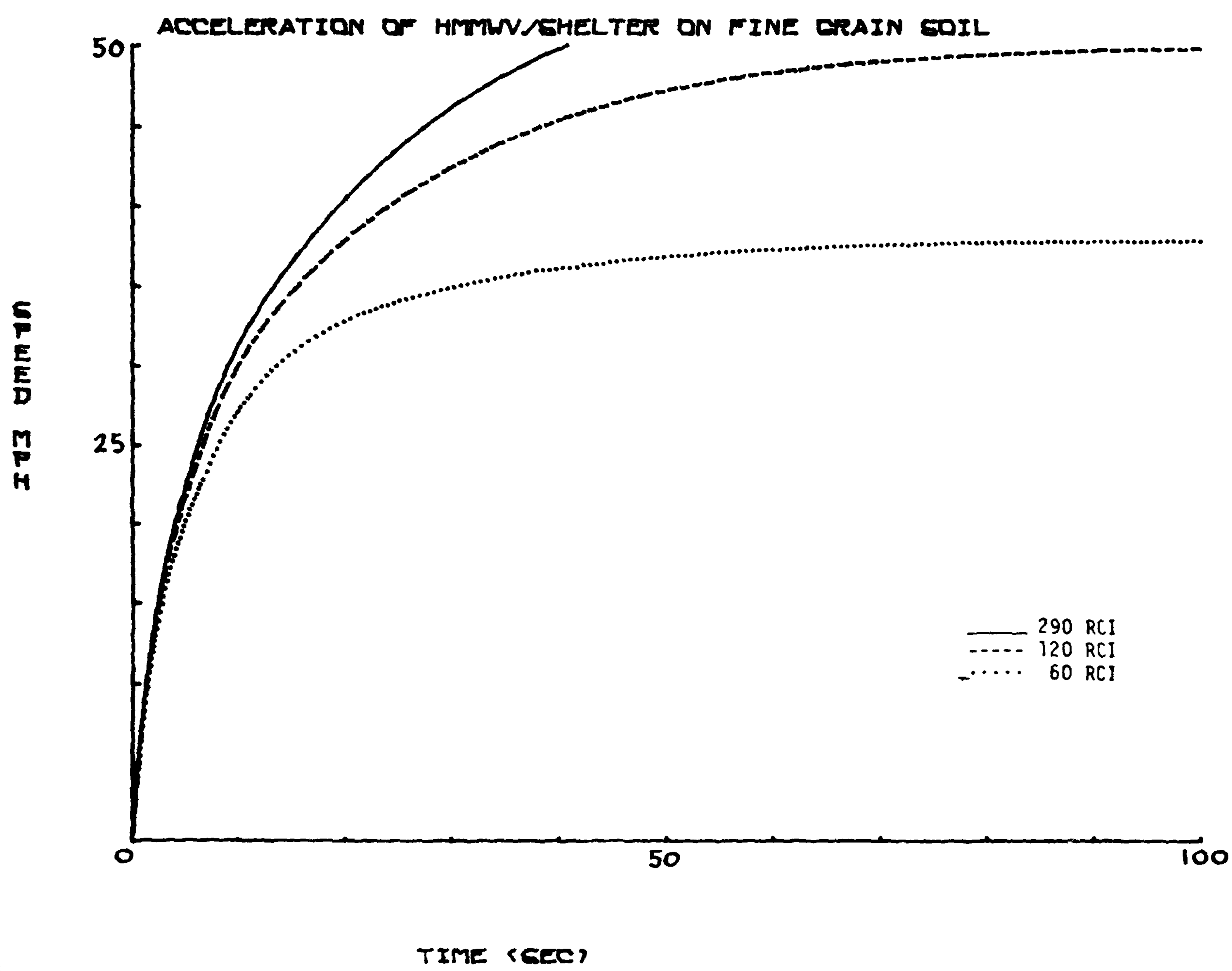

ACCELERATION OF M561-M101 ON FINE GRAIN SOIL
290 RCI
120 RCI
60 RCI
50
25
0
50
100
TIME (SEC)


ACCELERATION OF M151/AMMO TRAILER ON FINE GRAIN SOIL
50
40
30
20
10
0
20
40
60
80
100
SPEED MPH
TIME (SEC)
290 RCI
120 RCI
60 RCI

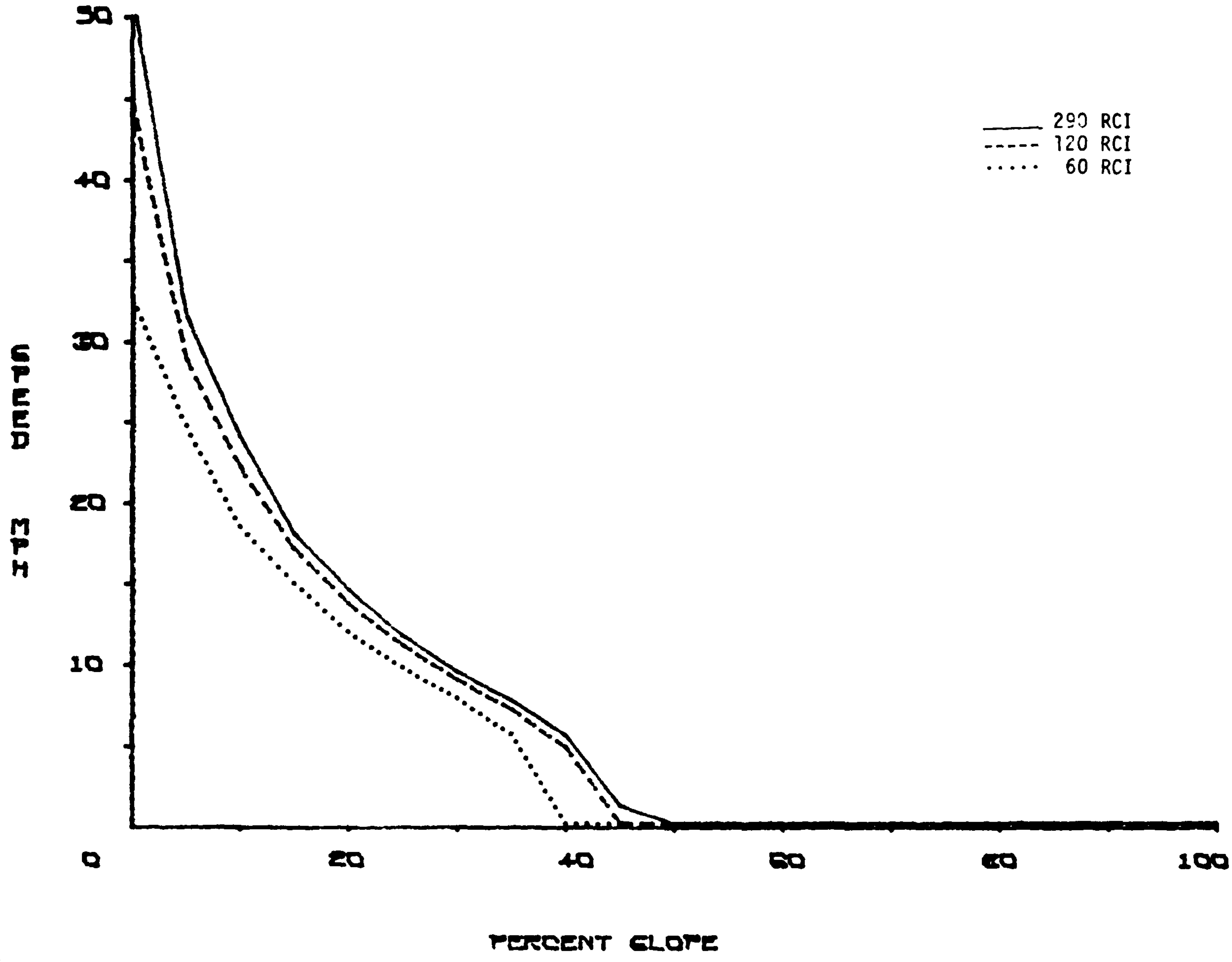

ACCELERATION OF M151 A2 ON FINE GRAIN SOIL
SPEED MPH
TIME (SEC)
290 RCI
120 RCI
60 RCI
0
10
20
30
40
50
0
20
40
60
80
100


ACCELERATION OF M551 ON FINE GRAIN SOIL
SPEED MPH
TIME (SEC)
50
25
0
50
100
290 RCI
120 RCI
60 RCI

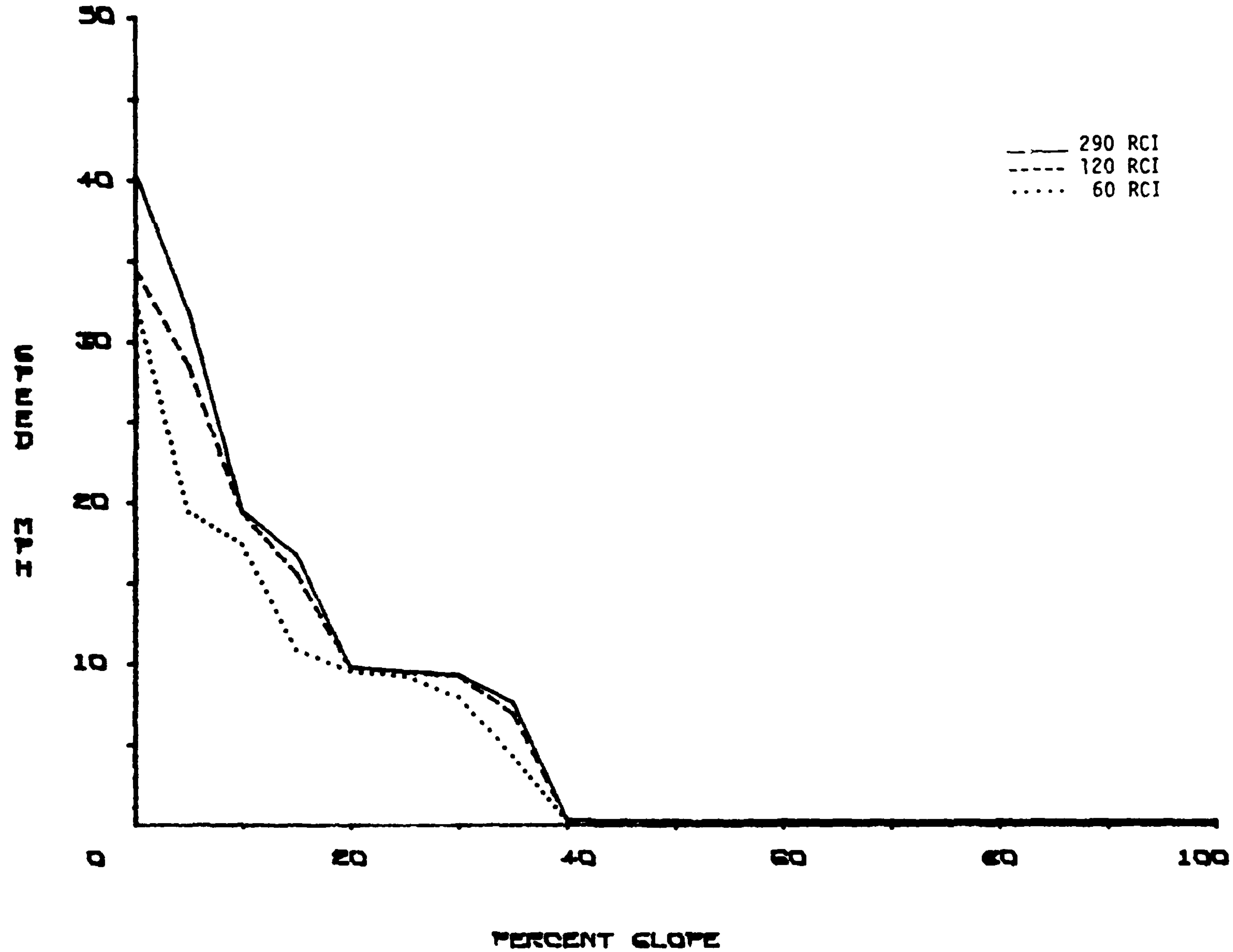

ACCELERATION OF GENERIC HMMWV ON FINE GRAIN SOIL
SPEED MPH
50
25
0
50
100
TIME (SEC)
290 RCI
120 RCI
60 RCI


ACCELERATION OF HMMWV/SHELTER ON FINE GRAIN SOIL
50
25
0
50
100
SPEED MPH
TIME (SEC)
290 RCI
120 RCI
60 RCI

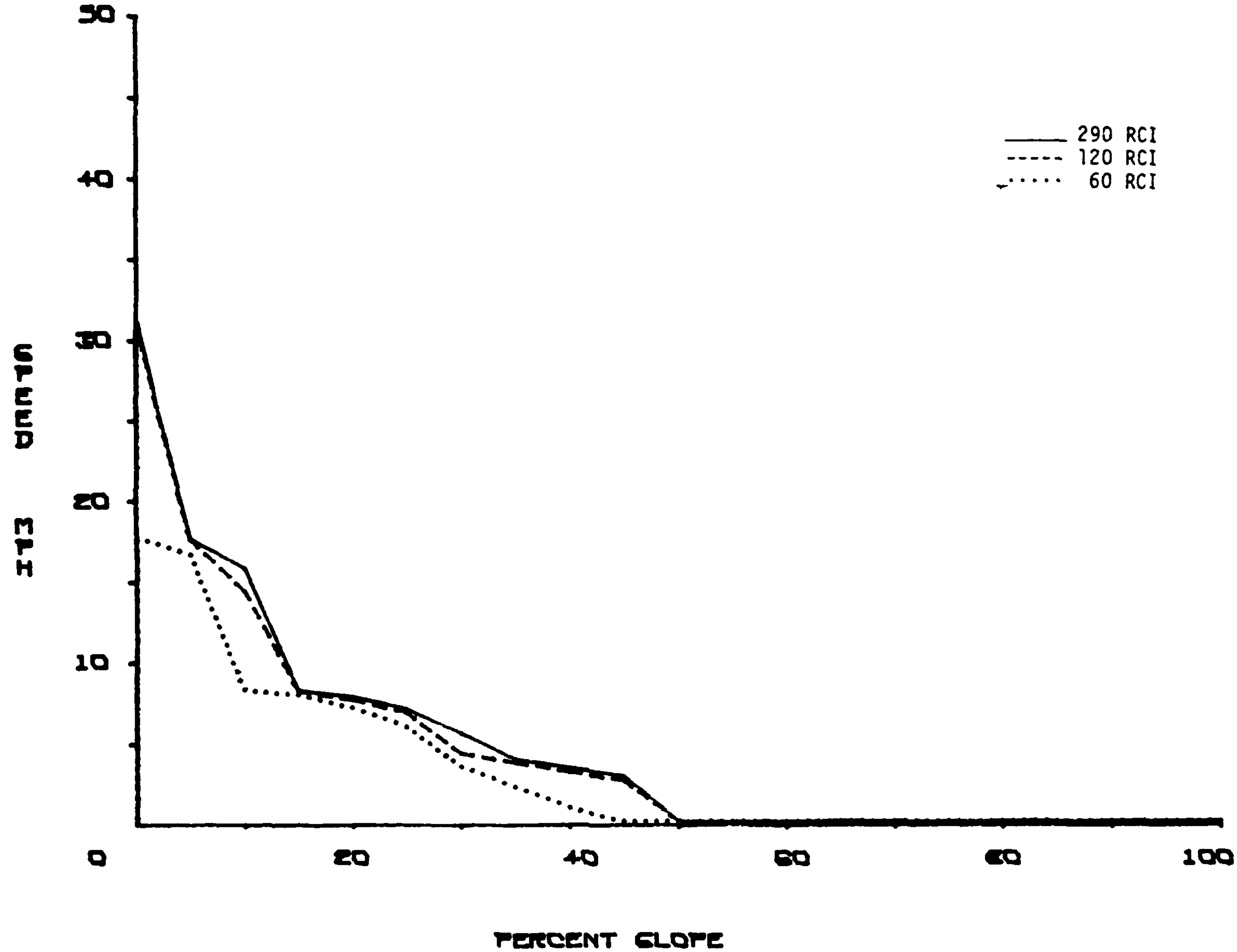
PERFORMANCE OF HMMWVTRL ON FINE GRAIN SOIL



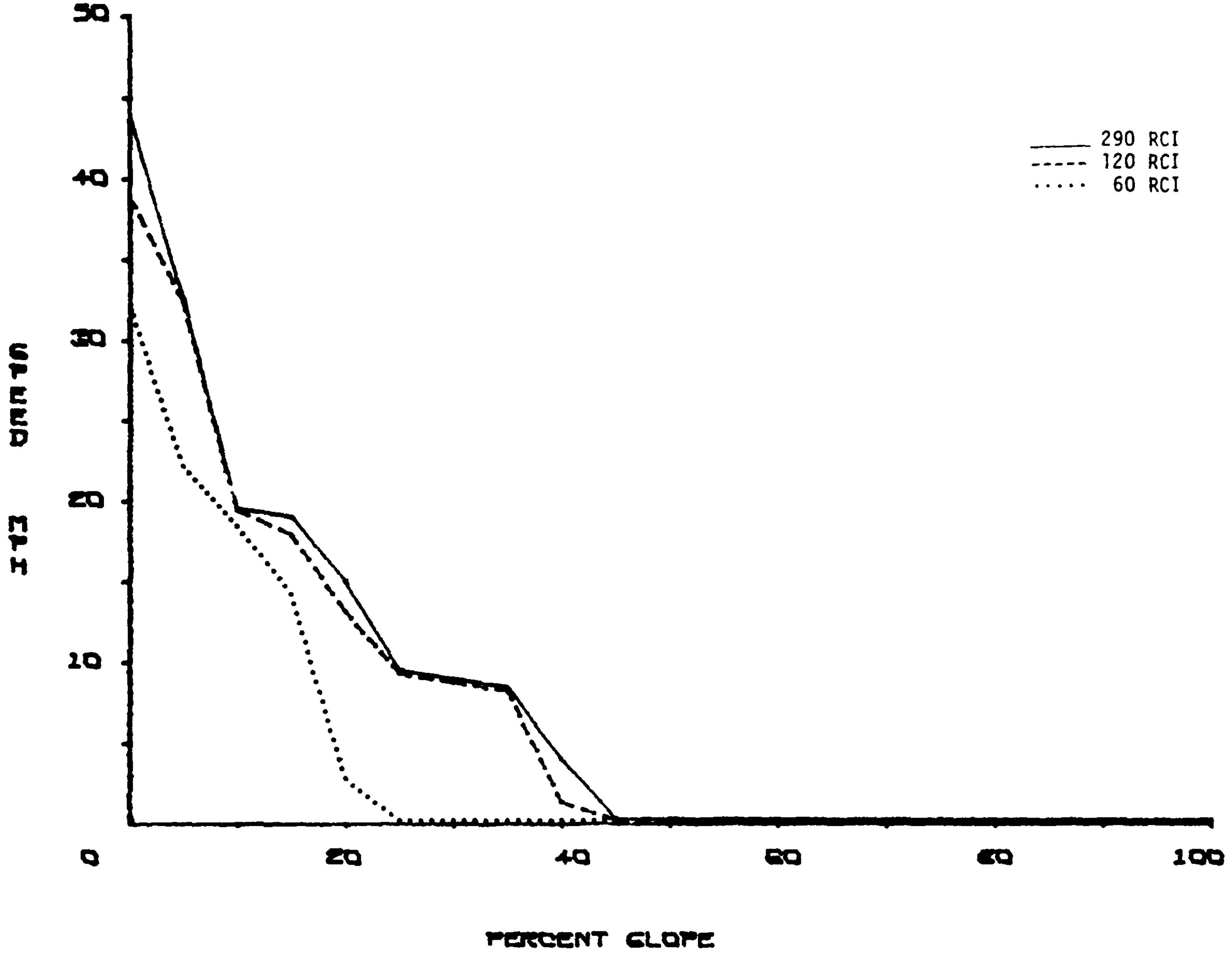
PERFORMANCE OF M151 WTR ON FINE GRAIN SOIL



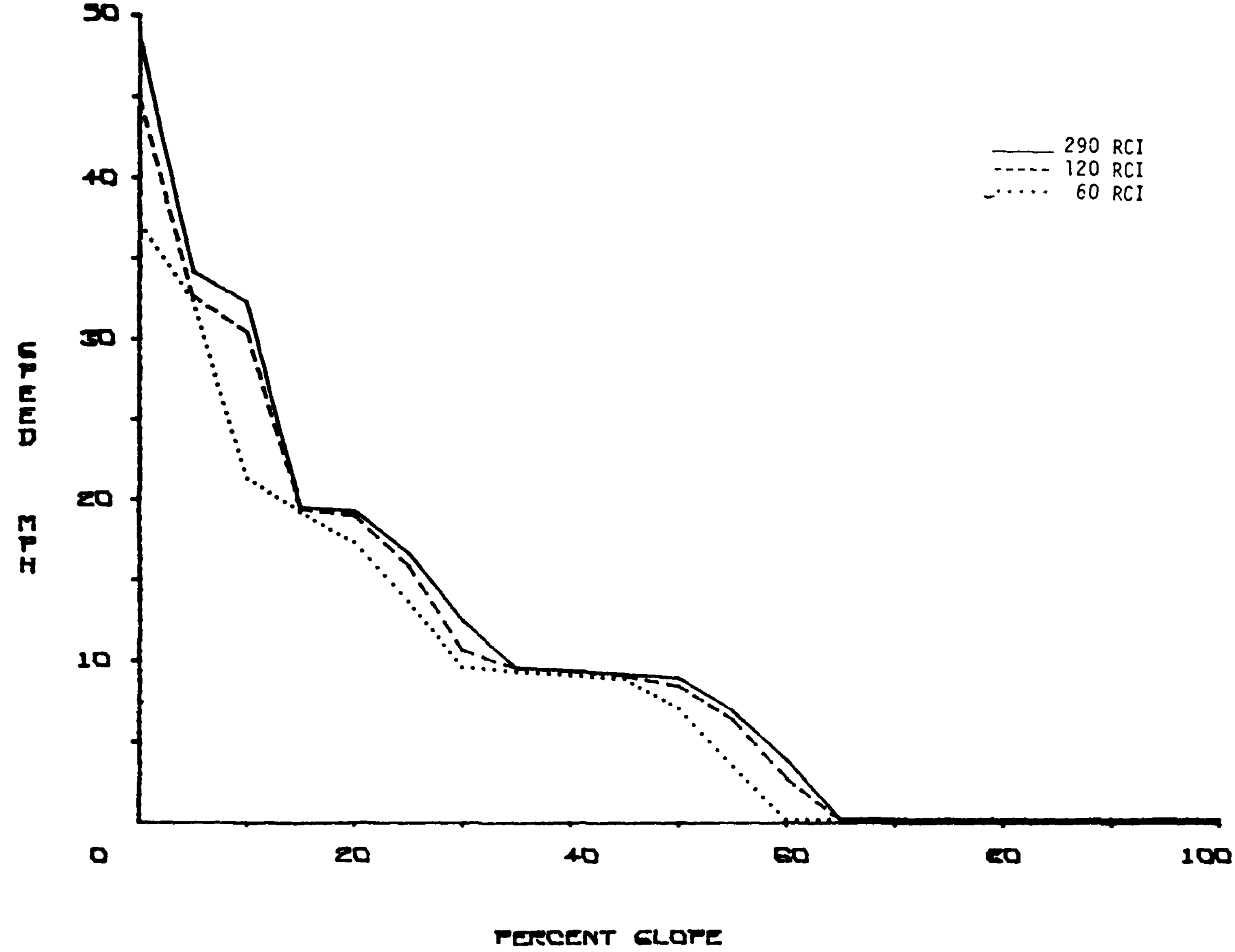
PERFORMANCE OF M561 TRL ON FINE GRAIN SOIL



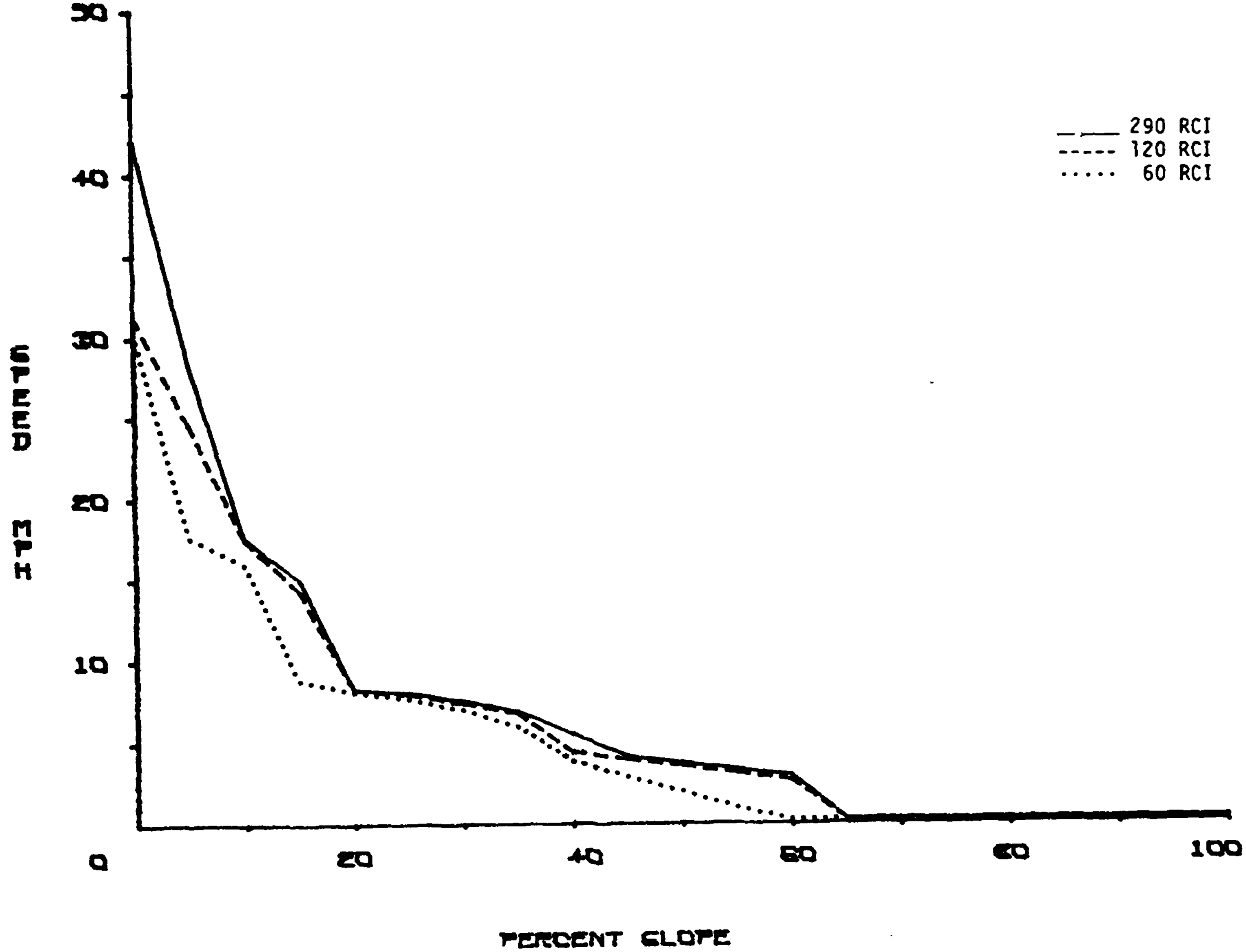
PERFORMANCE OF M151*MEL ON FINE GRAIN SOIL



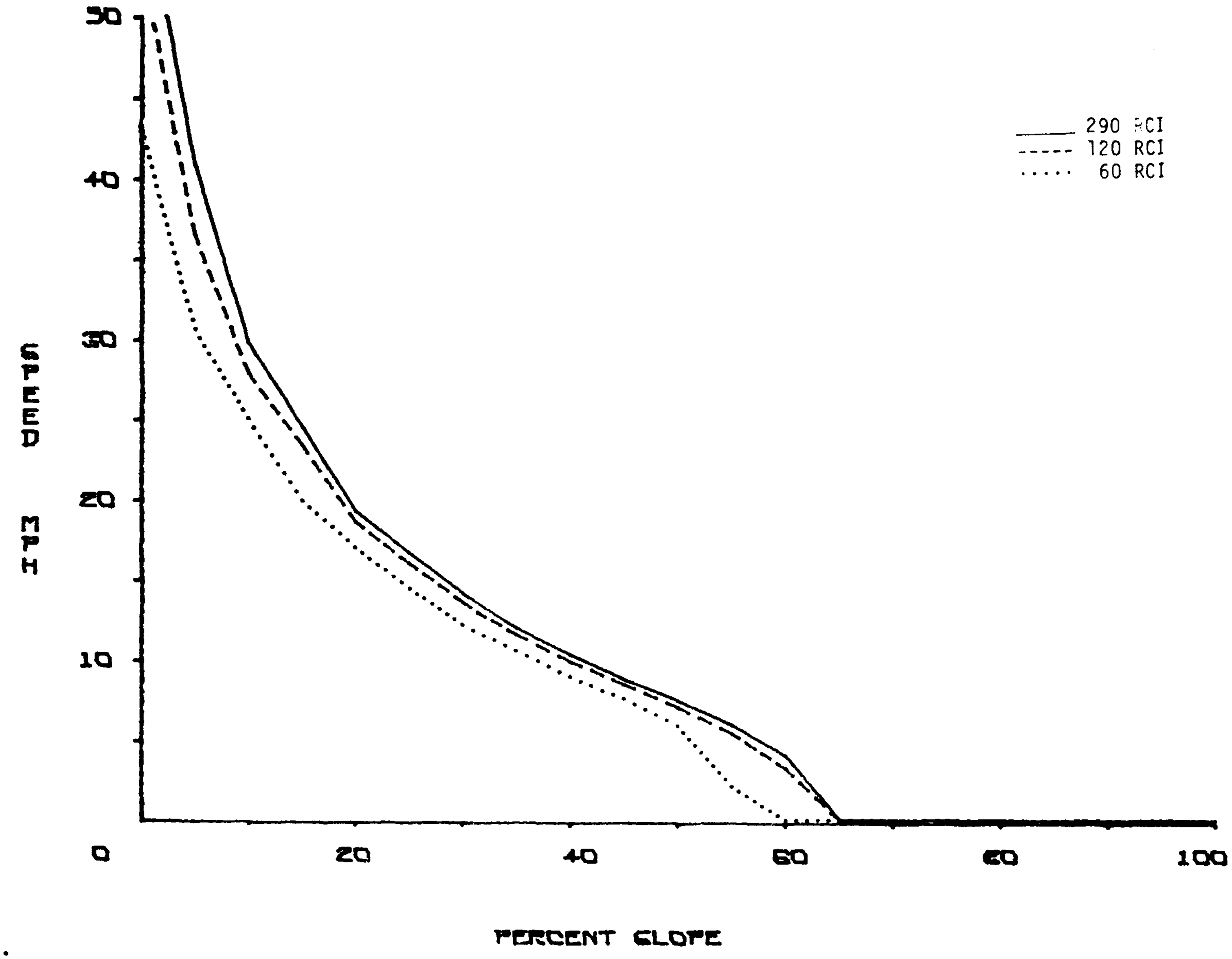
PERFORMANCE OF M151*A2 ON FINE GRAIN SOIL



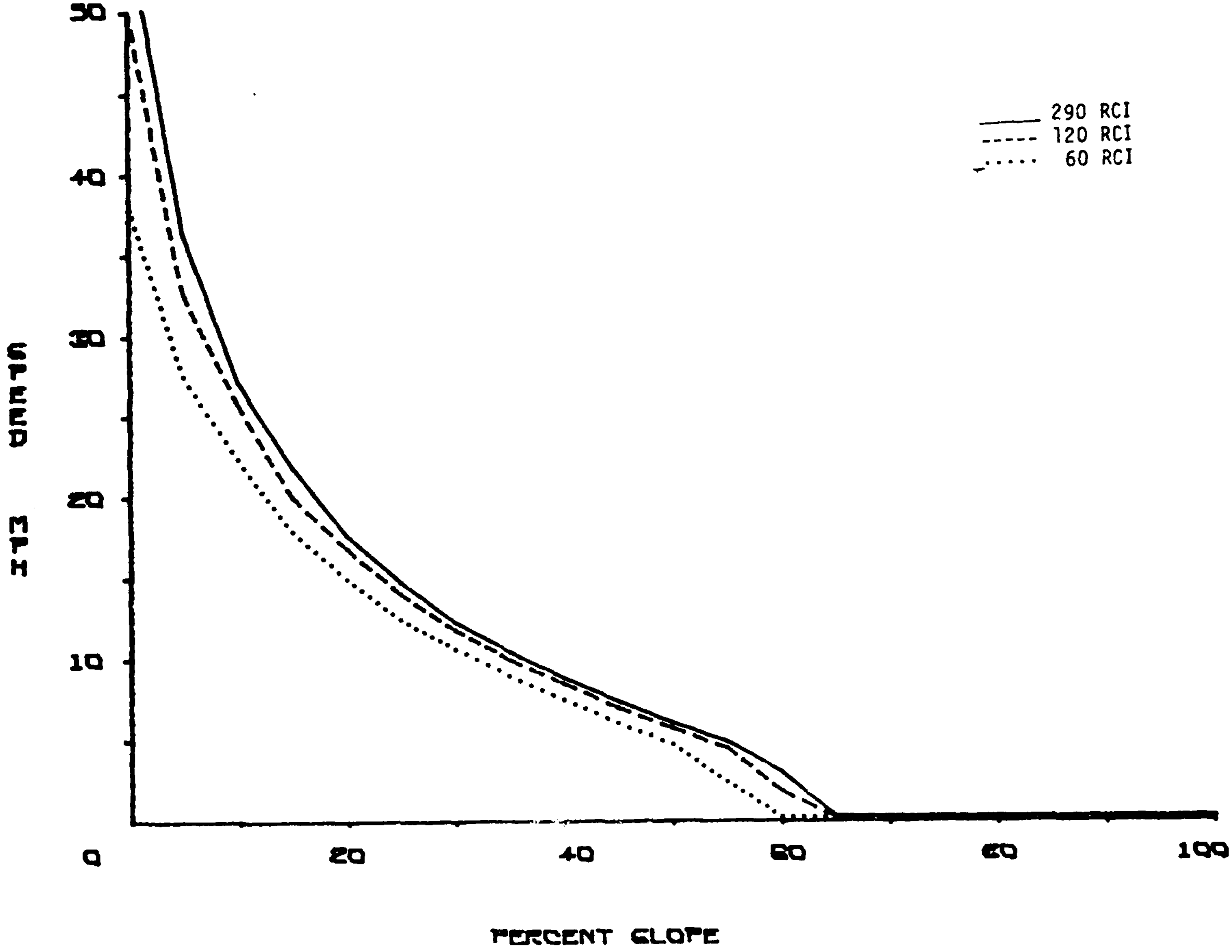
PERFORMANCE OF M551A ON FINE GRAIN SOIL



PERFORMANCE OF HMMWVG ON FINE GRAIN SOIL



PERFORMANCE OF HMMWVGH ON FINE GRAIN SOIL

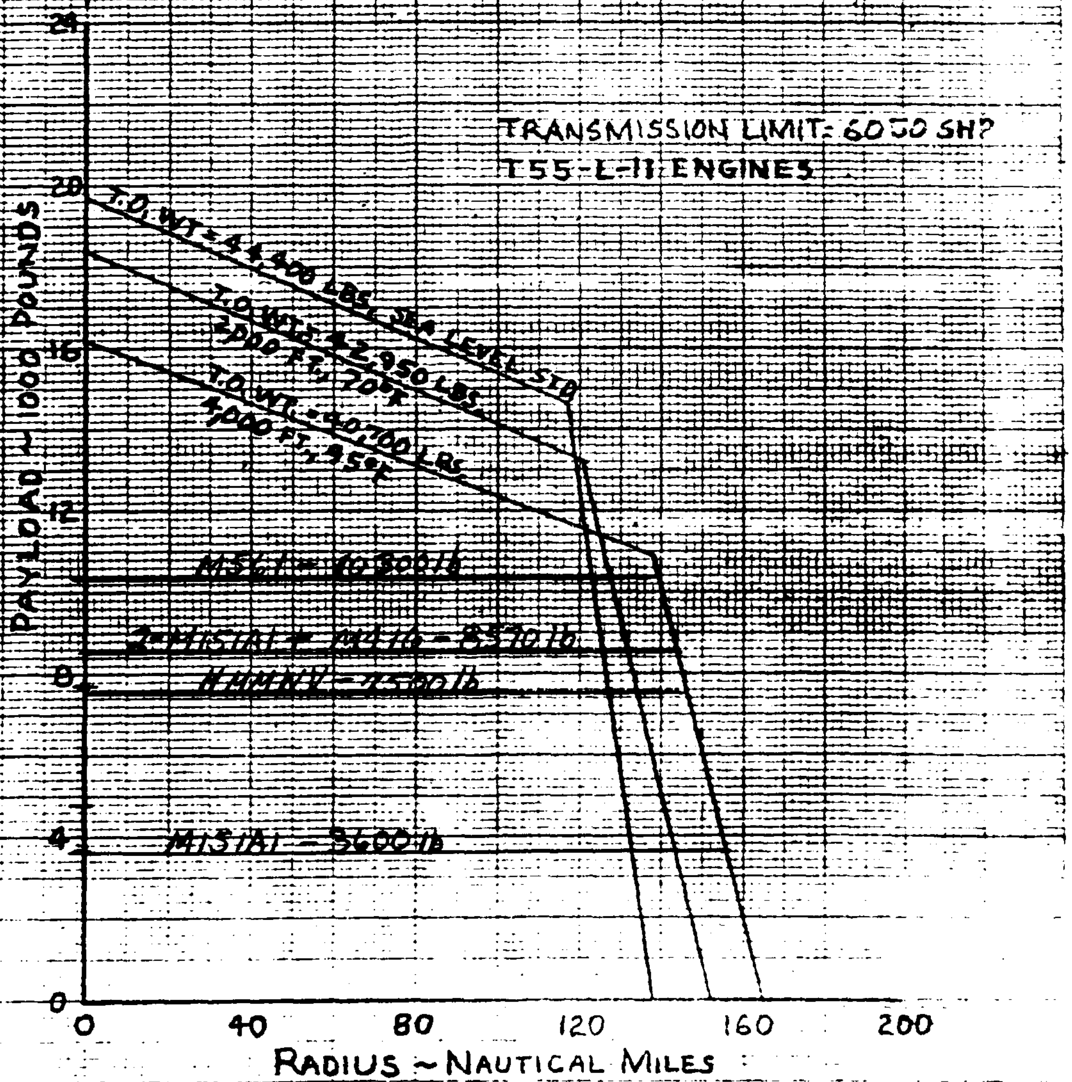


APPENDIX B

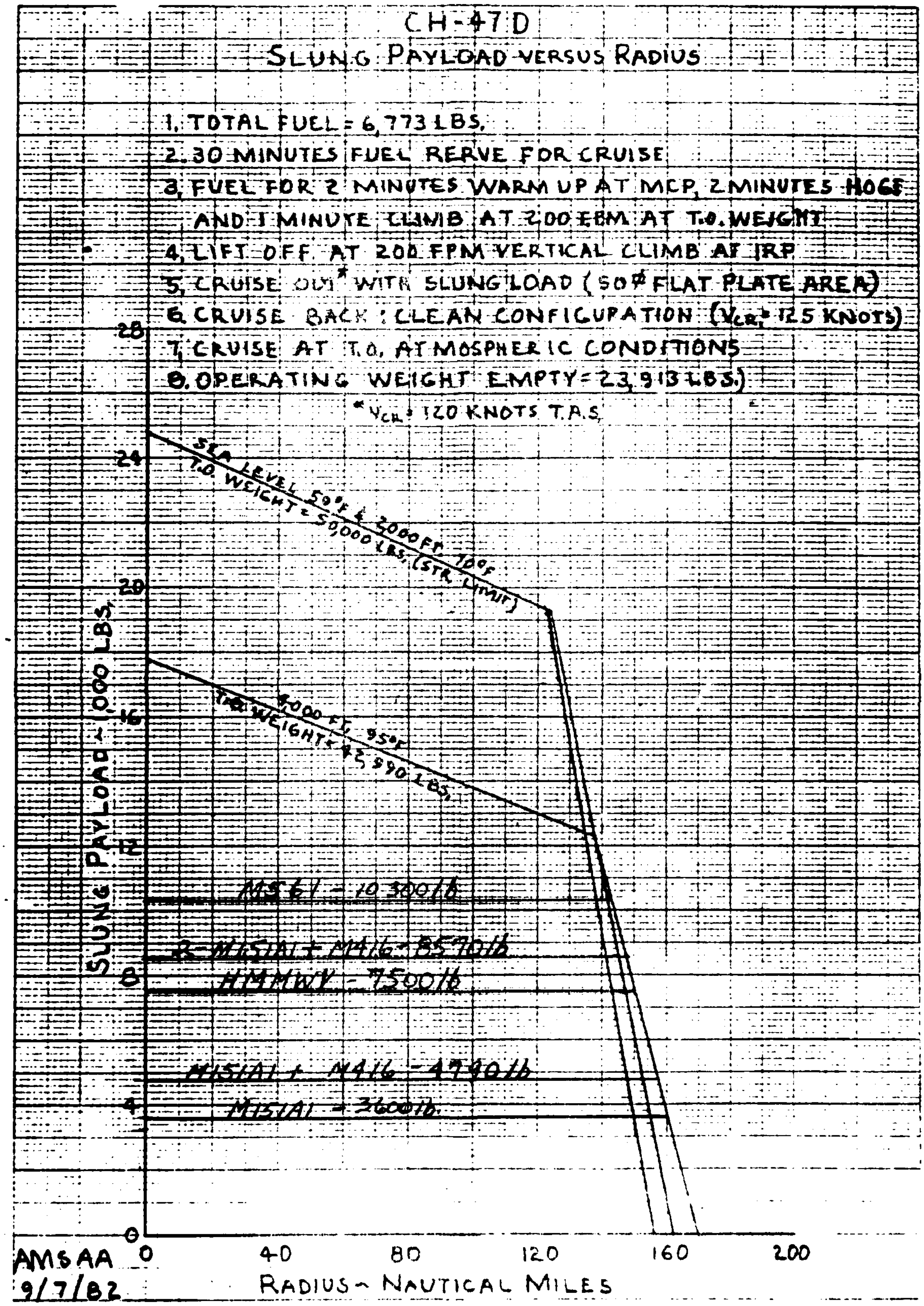
CH-47C

FIG. 1 PAYLOAD VERSUS RADIUS

1. TOTAL FUEL = 6773 POUNDS
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINS WARM UP AT MCP, 2 MINS HOGE AT TAKEOFF WT. AND 1 MIN. CLIMB AT 200 FPM.
4. LIFT OFF AT 200 F.P.M. V.R.O.C. USING 100% T.O. POWER
5. TAKEOFF & CRUISE AT ALTITUDE & TEMP. AS NOTED
6. CRUISE OUT WITH SLUNG LOAD OF 50 SQ. FT. FLAT PLATE AREA
7. CRUISE BACK - CLEAN CONFIGURATION
8. OPERATING WEIGHT EMPTY = 22,986 POUNDS

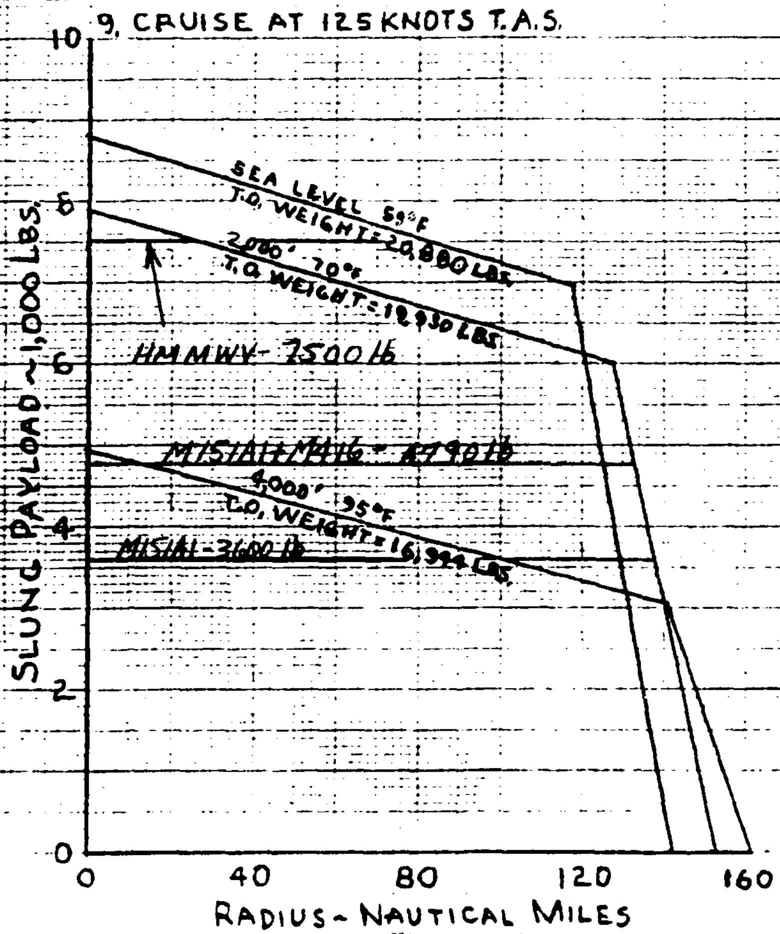


AMSAA 3/14/80


CH-47D
SLUNG PAYLOAD VERSUS RADIUS
1. TOTAL FUEL = 6,773 LBS.
2. 30 MINUTES FUEL RERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 FPM AT T.O. WEIGHT
4. LIFT OFF AT 200 FPM VERTICAL CLIMB AT IRP
5. CRUISE OUT* WITH SLUNG LOAD (50 ft² FLAT PLATE AREA)
6. CRUISE BACK: CLEAN CONFIGURATION (V_{CR} = 125 KNOTS)
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY = 23,913 LBS.)
* V_{CR} = 120 KNOTS T.A.S.
SEA LEVEL 59°F & 2000 FT 70°F
T.O. WEIGHT = 50000 LBS. (STR LIMIT)
4000 FT, 95°F
T.O. WEIGHT = 43,990 LBS.
M561 = 10300 lb
2-M151A1 + M416 - 8570 lb
HMMWV - 7500 lb
M151A1 + M416 - 4790 lb
M151A1 - 3600 lb
SLUNG PAYLOAD ~ 1000 LBS.
0
4
8
12
16
20
24
28
0
40
80
120
160
200
RADIUS ~ NAUTICAL MILES
AMSAA
9/7/82

BLACK HAWK
SLUNG PAYLOAD VERSUS RADIUS
SPECIAL UTILITY MISSION

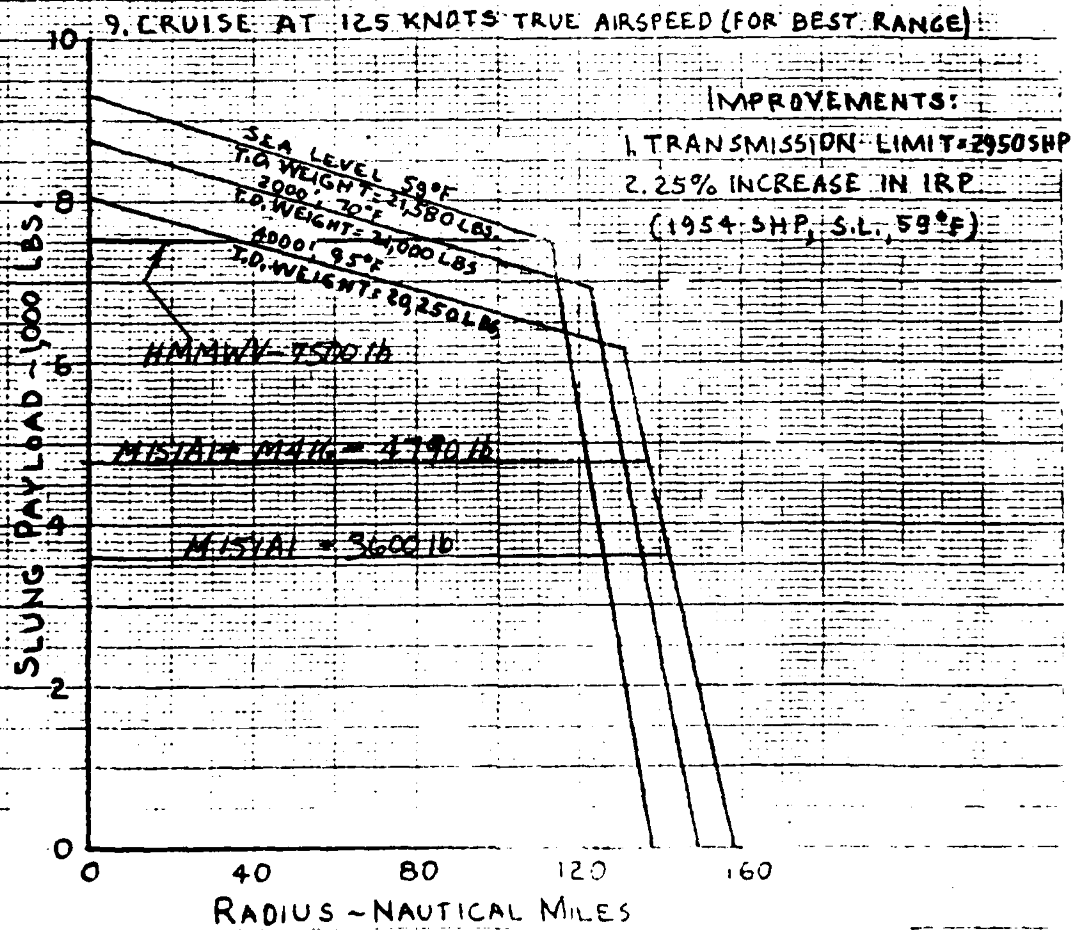
1. TOTAL FUEL = 2,350 LBS.
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 F.P.M. AT T.O. WEIGHT
4. LIFT OFF AT 200 F.P.M. VERTICAL CLIMB @ IRP
5. CRUISE OUT WITH SLUNG LOAD (24 ft² FLAT PLATE AREA)
6. CRUISE BACK: CLEAN CONFIGURATION
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY = 11,555 LBS.
9. CRUISE AT 125 KNOTS T.A.S.



AMSAA
8/11/82

IMPROVED BLACK HAWK
SLUNG PAYLOAD VERSUS RADIUS
SPECIAL UTILITY MISSION

1. TOTAL FUEL = 2,350 LBS.
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 FPM AT T.O. WEIGHT
4. LIFT OFF AT 200 FPM VERTICAL CLIMB @ IRP
5. CRUISE OUT WITH SLUNG LOAD (24 ft² FLAT PLATE AREA)
6. CRUISE BACK: CLEAN CONFIGURATION
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY = 11,735 LBS.
9. CRUISE AT 125 KNOTS TRUE AIRSPEED (FOR BEST RANGE)



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